Electrochemical and Metallurgical Industry

VOL. VII. NEW YORK, AUGUST, 1909 No. 8

Electrochemical and Metallurgical Industry

With which is incorporated Iron and Steel Magazine

Published Monthly by the
ELECTROCHEMICAL PUBLISHING COMPANY
239 West 39th Street, New York

EUROPEAN OFFICE, Hastings House, Norfolk St., Strand, London, Eng.

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Yearly subscription price for United States, Mexico and United States dependencies, $2.00; for all other countries, $2.50 (European exchange, 10 shillings, 10 marks, 12.50 francs).

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Entered as Second-Class Matter, June, 1903, at the Post Office at New York, N. Y., under the Act of Congress, March 3, 1879

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The Proposed New Home of the Chemists' Club.

The note, printed elsewhere in this issue on the new proposed Chemical Building to be erected by the Chemists' Club of New York, will be of interest to every chemist in the United States. The Chemists' Club has always lived up to the program of its founders to make it the professional home of all chemists of this country. In its cosy club house the various chemical societies have met and felt at home. "There the young graduate comes in contact with the teacher of our science who has made an international reputation for himself, and there the young beginner with the proud distinction of earning $15 per week meets on an equal social footing the millionaire captain of industry." It is not too much to say that the New York Chemists' Club has created a true democracy of American chemists. It is natural that it desires a bigger home. And if this is successfully attained, the more difficult task will also be solved to transplant the old spirit into the new home.

The Labor Problem.

Dr. Dudley's admirable presidential address to the American Society for Testing Materials on the subject of engineering responsibility contains a brief side remark on the labor problem. This remark is so pertinent that we quote it here without further comment, besides saying that, after labor unions have evidently come to stay as an essential part of the modern industrial system, they are necessarily subject to the same evolution as the system of which they form a part. Dr. Dudley says: "We are firmly convinced that if labor organizations would devote less time and energy to contention with employers and more effort toward making the organization stand for skill and plain, simple honesty in workmanship, and for fair dealing with, and reasonable devotion to, the interests of employers, all questions connected with the recognition of the union would fade into insignificance, and collective bargaining would be welcomed, nay, even sought for, by those who are managing the great industries of our modern civilization."

Electrode Losses.

Mr. C. A. Hansen's article in this issue brings up a very interesting and most important problem in electric furnace design. Since the electrodes are the means for transporting electrical energy into the furnace, they must be good electrical conductors, and since there is in general a close parallelism between thermal and electric conductivity, it is clear that with respect to the heat insulation of the furnace the electrodes are liable to form the weakest point with improper design. That much can be done, however, by properly dimensioning the electrodes is evident from the results described in Mr. Hansen's article. One of Mr. Hansen's results is that within reasonable limits the efficiency of a graphite electrode increases rapidly with increasing current density (or, what is the same, with decreasing cross-section). The research laboratory of

the General Electric Company must be congratulated on having taken up a systematic investigation of this important problem and further reports by Mr. Hansen on the results of this investigation will be awaited with great interest.

Gas Producers for Low-Grade Fuel.

In various instances in recent years we have witnessed remarkable changes in the attractiveness of low-grade ore propositions. Deposits which would not have been touched so very long ago are now being worked successfully. This is generally the result of high-grade ores getting scarce, together with advances in metallurgical art. As a matter of fact, both these elements are intimately connected, as necessity is the mother of invention. It seems that we are about to witness quite an analagous development with fuel. Forced by necessity, Europe has already largely made use of lignite and peat. With the enormous deposits of these low-grade fuels in this country, we certainly must expect that they will be used when we know how. But it is likely that the development will not by any means be exactly parallel to the development in Europe, in view of the differences of conditions. In Europe dry distillation of peat and lignite, with recovery of by-products, has proved attractive, though their use in gas producers has also been tried. In a discussion of this subject, in our October issue, 1907, we said that we do not expect great developments in this country along the lines of by-product coke ovens for peat and lignite, and that our hopes rest rather in the gas producer for low-grade fuels. We are glad to see that the same position is taken in the interesting paper of Dr. Zwingenberger, presented at the Brooklyn meeting of the American Institute of Chemical Engineers, and published in this issue. His reasons why he advises not to attempt the recovery of by-products in plants of moderate size, say of 1000 or 1500 hp, are certainly commercially sound.

* * *

Dr. Zwingenberger's paper is, however, especially interesting in the discussion of the fundamental problem—the proper design of the gas producer for these low-grade fuels. Much very valuable work has already been done by the U. S. Geological Survey in its extended gas producer tests. Dr. Zwingenberger's producer is a combination of gas producer and coking chamber, and the design is original in various respects. A principal difference between his coking oven or gas producer and other designs is that in the latter the gas leaves the producer at the top or center of the producer, while it leaves the Zwingenberger producer at the bottom. This is due to the desire to change the fuel wholly into gas and to avoid the formation of tar—which is a source of great trouble in the use of peat or lignite. In the Zwingenberger construction the tar formed passes through the zone of medium temperature, where a great deal is transformed into permanent gas, while the little rest cannot escape decomposition, because before leaving the producer it has to pass through a very hot zone, the temperature of which is close to the hottest zone of the combustion chamber. It will be interesting to watch how this design will behave in commercial continuous operation. At any rate, Dr. Zwingenberger's paper brings out clearly some of the principal points that must be considered in gas-producer design for lignite and peat.

The Active Forces in the Iron and Steel Industry.

"Oh, wad some power the giftie gie us, to see oursells as ithers see us." So, too, would that we could burst the trammels of the now and from a remote spot, shorn from the limits of time, view the course of the iron and steel industry through the years with the present marked only as by a milestone. The resolution of forces acting at a given instant is simple, but the course over a period of time is a curve made up of an infinite number of tangents, each a resolution of the forces acting at the moment. The forces change in direction and in intensity. They even disappear, while new ones appear. What a multitude of forces there have been. Many centuries ago the desire to kill produced the Damascus blade, then the need of defense produced armor. The harnessing of steam, of electricity, and of the inflammable gases have come in their turn. Each of these instruments brought into use has exerted a double influence, facilitating production and stimulating consumption. The history of the development of these three utilities is the history of the development of the iron and steel industry, with but few chapters omitted. Among the most distinct of the many forces acting at the present moment are the demand for fine steel for automobiles and flying machines, children of the gas engine, and the facilitating of the production of fine steel through the use of electricity. For illustrating our thought reference to mathematics can be made, but for seeking the desired view the science is useless because we cannot furnish it the infinitude of data without which it could not proceed. We are driven to a mere tracing of the variations which have occurred in the most prominent forces acting through the past to the present. None has disappeared. The desire to kill, which produced Damascus blades in pounds, now produces Dreadnoughts in thousands of tons. The merest approach to a real analysis is impossible, when a book could contain little. Here there can be but a few random words, and they will not have failed of their purpose if they succeed in directing a moment's thought to some few of the forces acting to produce the course of the iron and steel industry.

* * *

Until 1905 the curve of the world's production of pig iron was unmistakably convex to the axis of abscissae. From 1905 through 1907 it was concave, but still trended upward; in 1908 it dipped downward. It had done so before in individual years. The smoothing curve of the future may obliterate these movements as trifling irregularities. In the United States the curve of pig-iron production has diverged but slightly from that written by a mathematical law; the movement has been practically that of doubling the tonnage every 10 years. The divergences have been chiefly in individual years. The decennial periods closing with 1907 have shown the following tonnages:

1828-37	2,000,000
1838-47	4,300,000
1848-57	6,500,000
1858-67	8,760,578
1868-77	19,984,735
1878-87	42,484,217
1888-97	82,236,958
1898-1907	181,470,757

Through 1867 the curve was convex to the axis of abscissae,

but the curvature fell short of that in the mathematical curve mentioned; since 1867 the curvature has exceeded it. No such curve can be continued indefinitely. Civilization is thousands of years old, and we are dealing with tens of years. Noting that production in 1908 was less than two-thirds that of 1907 and 12 per cent less than the average in the 10 years ending 1907, while 1909 production is falling much short of 1907, one might, at a glance, suggest that the limits of the decennial periods have been injudiciously chosen, but a scrutiny of annual figures shows that no division would fail to produce a curve closely adhering to that written by a doubling every 10 years. Thus it remains that the curve has heretofore been convex to the horizontal axis. The knowledge that the dip in 1908 was caused by a financial panic the effect of which has largely worn off, and other considerations, including the increase this year, assure us that no permanent downward dip has been established, but whether the direction of curvature has been, or is being, changed at this time cannot be determined by this means. We can hardly draw a tangent at the present; it is utterly impossible from the data already cited to project the curve.

* * *

A simple proof that we cannot is furnished by a reference to statistics of steel production. At a given moment steel production and pig-iron production are in relation, but at different periods the relation varies. We made pig iron before steel. Prior to 1875 the tonnage of steel ingots was less than 10 per cent of the tonnage of pig iron; in 1906 and 1907 the tonnage of steel ingots and castings exceeded 90 per cent of the pig-iron production. The causes of the changing relation are well understood. The steel has been supplanting iron used in other forms, the ingot statistics are robbed of part of their value by including the remelting of new steel scrap produced in the rolling mill, and there is old material remelted. The production of steel has doubled every six or seven years. The production of rolled iron and steel, covering merchantable forms, increases rather slowly at first, but the last two doublings occurred in less than 20 years. The data cited are merely the quantitative statement of the result of influences which it would be burdensome to investigate. We should not yield to the fear that analysis of these quantities is useless for guidance, but should, on the contrary, see the necessity of going back to first principles. We make pig iron merely to accomplish the first metallurgical stage of converting the useless iron ore of the earth into useful material. The pig iron production is the addition to our store of useful material. It is at the blast furnace that we should measure the flow of the stream; there are no subsequent additions except the minor one to be noted. Material is lost by oxidation and by passing through uses which leave it in too small pieces to warrant reclamation. Portions of the store in use are reworked at longer or shorter intervals, a detail which is becoming increasingly important to the general alignment of the industry. As representing the flow of formerly useless material into actual use, the blast-furnace or pig-iron statistics are incorrect in two particulars; some ore passes through the open-hearth furnace and not through the blast furnace and some scale or other reoxidizing iron passes through the blast furnace. These particulars are relatively unimportant, and it chances that the signs of the corrections due to them are opposite.

* * *

The atmosphere seems clearer when we look at our store of iron, rather that at our annual production, to determine our tangents or produce our curves. What is the present store? To the middle of this year we have made 375,000,000 tons of pig iron in the United States. This iron was produced by each decade, making approximately double as much as the preceding decade; if this had been done strictly, the production of a decade would have exactly equalled the total previous production. Our present store of iron and steel, expressed in terms of pig iron required to make it, is perhaps two-thirds the total production, or somewhere in the neighborhood of 250,000,000 tons. It has required a third of a century for our population to double, so that the increase in population has borne no important relation to the increase in requirements. When our population was half as large as at present we had made only one-eighth as much pig iron. There has been produced for domestic use about 50,000,000 tons of steel rails, and there are in use about 40,000,000 tons. We have built steam railroads until we have a mile for every 13 sq. miles of area, and are not building as rapidly as formerly. In a few years we have had a rush of replacing wooden cars with steel construction, and may be able to proceed more moderately in future. We have erected steel office buildings to house several millions of our population.

* * *

Without going farther, what do these achievements promise? The curve of production in these directions is not likely to be so convex to the horizontal axis as has been the curve of total production or the curve of our total store. The curve may even change its direction of curvature, although still trending upward. Let us forsake tonnage considerations for a moment and observe if there is anything else to be seen. The time was when iron rails were used, averaging, say, 45 lb. to 65 lb. per yard. Such rails would nowadays last the time required for the passage of the first pair of drivers of a modern locomotive upon them. Then came the light steel rail, then heavier sections. The traffic per mile of road has greatly increased, especially on trunk lines; the life measured in volume of traffic may have decreased; measured in time it has greatly decreased. The annual sinking fund for replacement has risen and is larger proportionate to interest charge, dictating, with mathematical precision, the employment of finer steel to decrease greatly the sinking fund charge while increasing but slightly the interest charge. A practical illustration is the installation at Gary to make 300 tons of electric steel rails a day. The height of office buildings and the length of bridge spans has been pushed until the loads compel higher tensile strengths at higher costs per ton of material. The demand for fine steel for automobile construction is growing wonderfully; the general manager of the American Motor Car Manufacturers' Association estimates that plans for next year call for building 200,000 cars, against 70,000 cars this year; the tangent to that curve of demand is almost vertical at the moment. We may be in doubt whether the curve of tonnage will remain convex to the horizontal; we cannot doubt that the curve of quality is strongly convex.

The Proposed New Home of the Chemists' Club in New York.

A site has been secured for the proposed new Chemical Building in New York City. After long and careful search by a committee, headed by Dr. Charles F. McKenna, a plot 56 ft. x 100 ft. at 50 to 56 East Forty-first Street, has been selected, and the negotiations for its purchase have now been brought to a satisfactory close. The land will be held at the disposal of the friends of the Chemists' Club until it shall have been definitely ascertained whether the plans can be carried out within a reasonable time.

The property is within a two-minutes' walk of the Grand Central Station, the Subway Express Station, and the proposed terminals of the tunnels to Long Island and New Jersey; while the proximity to the New York Public Library, in Fifth Avenue, opposite Forty-first Street, and the Engineering Societies' Building, in Thirty-ninth Street, accentuates the wisdom of the choice. At the same time, Forty-first Street is interrupted by the New York Public Library and the Park Avenue cut and can never become a thoroughfare for heavy traffic.

A real estate company is to be formed to erect an 8 to 10 story building, the lower portion of which will be especially adapted to the needs of the Chemists' Club and its allied societies.

The upper floors will be constructed with a view to accommodating the laboratories and offices of analytical, research and commercial chemists, physicists, sanitary and pathological experts. Some of the special attractions, besides well-lighted and ventilated space in a properly constructed scientific building, would be joint telephone service, the availability of a large scientific library, a co-operative storeroom for standard apparatus and chemicals; possibly the provision of special apparatus for that class of operations which are only occasionally performed in any one laboratory.

If a sufficient demand be demonstrated, bedrooms can be provided for individual chemists or the club may decide to provide sleeping accommodations for its members.

The success of the plan will depend upon the readiness with which friends of the club will purchase the stock of the company. At present a canvass is being made among the members of the club to get exact information on certain concrete questions which will decide the probable income, the cost of construction, etc.

Dr. Morris Loeb is the president of the club.

The Iron and Steel Market.

The decrease in buying of steel products in July was less than expected. While there has been no large business done the flow of small orders has kept up very well. Additional specifications have been received on old contracts, reinforcing the large mass received in the second quarter, so that altogether the steel mills have an ample supply of business on which to operate in the usually dull summer months.

The trend of steel prices has been slightly upward, but the movement is not necessarily important as regards the future, as much will depend on the relation between demand and capacity. When mills have advanced prices it has been chiefly through the encouragement derived from there being a large tonnage under contract, specifications against which are stimulated by advances in the open market.

The iron and steel market has been particularly the creature of sentiment this year. A large part of the trade may be said to have been plunged in the depths of despair when the price maintenance policy was abandoned Feb. 18, to make way for such competition and price reductions as would bring a larger volume of business, while during the second quarter optimism grew rapidly so that by the end of June the position and prospects were regarded with almost unbounded enthusiasm.

The changes in actual conditions have been of much less range than the changes in sentiment. The actual rate of output of finished steel products probably has not shown a variation of as much as 10 per cent above or below the mean during the first seven months of the year. The rate of pig-iron production has shown considerably less variation than this, but that rate has not been strictly indicative of the steel-making rate, for the reason that when the steel trade was quietest the merchant furnaces were accumulating pig iron, while of late when the steel mills have been more active the merchant stocks have probably been drawn upon.

It is of interest, however, to note that the total pig-iron production in the first half of the year was about 11,000,000 tons, while the lowest rate shown for any month in the half year would have resulted in an output of fully 10,500,000 tons and the highest rate shown for any month would have resulted in an output of somewhat less than 12,000,000 tons, so that the extreme rates varied from their mean by only about 6 per cent. The June rate, the maximum of the half year, was a trifle under 24,000,000 tons a year, while the July rate has probably slightly exceeded 24,000,000 tons a year. The maximum rate recorded was 28,000,000 tons, in October, 1907, while the best calendar year's production, that of 1907, was 25,781,361 tons.

The month of July has seen an unusual number of labor disturbances, there being strikes against the Pressed Steel Car Company and Standard Steel Car Company, somewhat decreasing plate shipments of the mills; a threatened strike of coal miners against the Pittsburgh Coal Company, a minor strike of switchmen at McKeesport against the National Tube Company, and the serious conflict between the American Sheet & Tin Plate Company and its men. This company declared that after June 30 it would operate all its mills on the open-shop principle, its scale agreement with the Amalgamated Association, controlling the hot-mill labor in a little over half its sheet and tin mills, expiring June 30, and its agreement with the Tin Plate Workers' International Protective Association of America, covering about two-thirds of its tinning capacity, expiring July 15. After the first promulgation the open-shop order was modified so as not to become effective with tin-house labor until after July 15.

The night of June 30 all the Amalgamated Association men walked out with the exception of those in the Guernsey sheet mill, at Cambridge, Ohio. The night of July 15 all the tin-house organization's men walked out except a few at the two New Kensington plants. Thereupon the company commenced its efforts to operate the closed plants with non-union labor, while the unions started their efforts to close the non-union plants which had been operating. The honors have been about equally divided, which is a surprise since the more general expectation, and certainly that of the company itself, was that no very serious resistance would be offered.

Pig Iron.

Pig iron has been strong in all markets, but without noteworthy advances except in the case of Southern iron. At the close of June the $11.50, Birmingham, price for third quarter had been withdrawn by many interests; early in July it disappeared entirely, and after a few sales at $12, the market advanced squarely to $12.50, Birmingham, for third quarter and $13 for fourth quarter, an advance of $1.50 from the beginning of June to the middle of July.

The International Harvester Company and American Radiator Company have been the largest purchasers of Northern and Southern foundry iron, each taking in the neighborhood of 50,000 tons. Steel-making pig iron, particularly Bessemer, has been fairly active. There has been a moderate movement of basic in the Pittsburgh market, at $15, valley. Early in the month the Jones & Laughlin Steel Company bought 25,000 tons of standard Bessemer from the Bessemer Pig Iron Association at $15.25, valley, or $16.15 Pittsburgh, for third quarter delivery. July 13 the Youngstown Sheet & Tube Com-

pany bought an equal tonnage from the same interests at $15.50, valley, for delivery through October. Negotiations were then set on foot by the chairman of the furnace association to gather together all the Bessemer iron available for early delivery and offer a block to the United States Steel Corporation.

The valley market (Pittsburgh delivery 90 cents higher) is quotable as follows: No. 2 foundry, malleable and basic, $15 to $15.25 according to delivery; forge, $14; Bessemer, $15.50 to $16.

Billets and Sheet Bars.

Deliveries of billets and sheet bars were slightly reduced in July owing to some mills being closed for repairs and on account of labor difficulties. Bessemer continues quotable at $23 for billets and $25 for sheet bars, soft open-hearth steel commanding a premium of about $1 a ton. Forging billets have been advanced by most sellers to $27, the usual spread above rolling billets being $2.

Finished Materials.

The advances of $1 a ton noted in last report as made on bars, plates and shapes by a number of producers have been followed by similar advances by all other producers, and the market is squarely on the basis of $1.25 for bars and $1.35 for plates and shapes, quotations $1 a ton higher being frequently made. The concessions on sheets, which generally decreased during June, have been almost entirely withdrawn. Iron bars have become firmer, the former nominal price of $1.45, Pittsburgh, being fairly well established. Wrought-iron pipe has advanced a point, or about $2 a ton, steel pipe being unchanged.

The market is quotable as follows, f.o.b., Pittsburgh:

Steel bars, $1.25, base.

Iron bars, $1.45, base.

Plates, $1.35 to $1.40.

Shapes, $1.35 to $1.40.

Standard rails, $28 for Bessemer and $30 for onep-hearth, f.o.b. mill; light rails, 25-lb. to 45-lb., $26.50 to $27.50.

Sheets, 28-gage, black, $2.20; galvanized, $3.25.

Tin plates, $3.40 for 100-lb. cokes.

Merchant steel pipe, ¾-in. to 6-in., inclusive, nominally 80 per cent off in "jobbers' carloads"; actual inside price, 81 and 5 off.

Plain wire, $1.50, base; wire nails, $1.70, base; painted barb wire, $1.70; galvanized barb wire, $2.

Detroit Meeting of American Chemical Society.

The meeting of the American Chemical Society, held at Detroit, from June 29 to July 2, was more largely attended than any summer meeting in its history and all the members returned to their homes enthusiastic over the work accomplished by the various Divisions of the society.

Meetings were held by the Division of Industrial Chemists and Chemical Engineers, the Division of Physical and Inorganic Chemistry, the Division of Organic Chemistry, the Division of Fertilizer Chemistry, and the Division of Agricultural and Food Chemistry, and by the Sections of Biological Chemistry and Pharmaceutical Chemistry and the Section of Chemical Education. In all 186 papers were presented.

Besides the reading of the various papers the points of special interest were the largely attended meetings of the Division of Industrial Chemists and Chemical Engineers, where representatives were present from all parts of the country. Perhaps the "experience meeting" before this division on Friday morning was the most entertaining feature of their program, for many ideas of value were brought out and the discussion was general. It seemed as if almost every member had some interesting fact which bore upon the experience of others and the hour for adjournment was delayed to the very latest possible moment on account of the keen interest aroused. It is quite noteworthy that the mantle of secrecy which has enveloped so many of the chemical industries and industrial chemists in the past appears to be falling away under this enthusiasm and both the industries and the industrial chemists themselves find that they gain more than they lose thereby. In this connection it might be added that a considerable number of chemical corporations are joining the society as such and are heartily entering into the spirit of progress with which the society is so thoroughly imbued.

The Section of Pharmaceutical Chemistry, which held its first meeting in Baltimore, was surprisingly well attended at Detroit with representative pharmaceutical chemists from various sections of the country. The chief matter of importance before the section was the question of the advisability of forming a Division of Pharmaceutical Chemistry. After the matter was discussed by almost everyone present and many letters were read from pharmaceutical chemists, it was unanimously voted to request the council to establish such a division and a strong organization was formed with Prof. A. B. Stevens, of Ann Arbor, as chairman; B. L. Murray, secretary; J. P. Remington, Edw. Kremers and J. M. Francis, executive committee.

The social features of the meeting were many. A complimentary smoker was given by the Society of Detroit Chemists to the visiting chemists on Tuesday evening, and a banquet on Thursday night. On Wednesday afternoon the chemists were the guests of Parke, Davis & Company, and visited the works of this well-known firm, were entertained there at dinner and were given an evening boat ride on the Detroit River and Lake St. Claire before returning. Thursday was spent in Ann Arbor as the guests of the regents of the University of Michigan and three papers of general interest were there presented in general session. The rest of the day was turned over to the Section of Chemical Education, where papers dealing with methods of instruction were read. During the day the members visited the new laboratories of the University of Michigan, and were entertained at luncheon through the courtesy of the regents.

Many manufacturing works and chemical establishments were opened to the visitors in Detroit, among which may perhaps be especially mentioned Acme White Lead & Color Works, Detroit Salt Company, Hiram Walker & Sons, Hoskins Manufacturing Company and the various automobile factories which have so greatly added to the industrial life of Detroit.

A steadily increasing number of members of the society are making it a point to attend the meetings, and it is interesting to note that more and more chemical corporations are appreciating the value of these meetings to their chemists and are insisting upon their attendance, in most cases bearing all the expenses of the trip.

Electric Smelting of Iron Ore in Sweden.

With reference to the plans of the Trollhättans Elektriska Jarnverk, noticed in the letter of Mr. H. Hullegard, on page 300 of our last issue, another correspondent in Sweden sends us some further information.

The company has been incorporated with a minimum capital of 600,000 kr. ($160,000), the inventors having allied themselves with some prominent steel men as promoters of the organization. In this way the common interest of the Swedish manufacturers in the development of a successful process for the electric smelting of iron ore has caused them to combine for the purpose of obtaining experience in working the process on a commercial scale before entering upon what may be called "large scale operations."

The new works will be situated near Gothenburg at Trollhättan where large water-power developments have been carried out by the Swedish Government. The company has an option on 10,000 hp at a price of 37.50 kr. ($10) per kw-year for the first 10 years, and at 50 kr. ($13.40) for the following 10 years. Present plans cover the erection of three furnaces, two of which will be working while the remaining one will be held in reserve. Each furnace will have a capacity of 2500 hp, and will produce 7500 tons of pig iron a year. The intention is

to use coke as a reducing agent, because coke in this furnace gives a pig iron having qualities equal to that of the charcoal iron, and coke is cheaper than charcoal, which otherwise is used almost exclusively in Swedish blast furnaces. A suitable metallurgical coke can be obtained for 21 kr. ($5.63) per ton. The ore used will be shipped from the mines at Grängesberg, situated about 200 miles from the furnace, part of which distance is covered by water transportation.

The cost of producing one ton of pig iron in kr. (1 kr. = 1 Swedish crown = 26.8 cents) is figured as follows for a production of 15,000 metric tons of pig iron at Trollhättan:

		Kr. per ton pig.
1,700 kg. ore (60 deg. F.)	7.00 kr. per ton ore	
Freight to Trollhättan	4.50 kr. per ton ore	
Unloading at Trollhättan	0.30 kr. per ton ore	
	11.80 kr. per ton ore	20.00
300 kg. coke (21 kr. per ton)		6.30
100 kg. limestone (6 kr. per ton)		.60
One-third hp-year electric power (27.60 kr. per hp-year)		9.20
Salaries and wages, including crushing and transports		3.50
Cost of electrodes, 8 kg., at 0.25 kr		2.00
Maintenance and general expenses		4.50
Interest and sinking fund (11 per cent on ½×365,000)		2.70
Analyzing costs		.20
Office and organization		1.00
Royalty		1.00
Total per ton of pig		51.00

It is, therefore, calculated that the pig iron can be produced at cost of 51 kr. per metric ton, which is equivalent to $13.67 per metric ton, or $12.40 per short ton. It is assumed that the selling price will be at least 58 kr. per metric ton, or $14.10 per short ton. Therefore, with a production of 15,000 tons a year and a capital investment of 600,000 kr. the profits would amount to at least 15 per cent. The cost sheet for the plant is given as follows:

	Kronen.	Dollars.
Three electric furnaces of 2500 hp. including transformers, etc	150,000	40,000
Installation	15,000	4,000
Crushing machinery for 35,000 tons of ore and 7000 tons of coke per year	9,000	2,400
Motors, small transformers, lighting, etc	6,000	1,600
Apparatus for transportation of ore from docks to furnaces, etc	15,000	4,000
Apparatus for transportation of iron, slag, etc., in plant	12,000	3,200
Furnace building and storehouses	60,000	16,000
Building for crusher plant	4,000	1,060
Grading, fencing, work on docks	15,000	4,000
Office and laboratory	20,000	5,300
Superintendence and unforeseen expenditures	34,000	9,060
Total	340,000	90,620
Licenses	25,000	6,660
Working capital	235,000	62,720
Total	600,000	160,000

Some of the items given above, which are almost identical with those given by Mr. Hulleyärd in our last issue, seem to be somewhat optimistic, but it is to be hoped that the comfortable margin of profits calculated will make it profitable for the plant to carry somewhat heavier first cost than has been assumed.

The outcome of this enterprise will be watched with great interest by those acquainted with the development of the electric smelting of iron ore in places where conditions are favorable to such a process. So far the experimental furnace has been running only for a period to be measured by days or weeks, and it remains to be seen whether the design will stand the crucial test of running commercially over long periods. The successful outcome of the enterprise will in many cases have an important bearing upon the iron industry.

Engineering Responsibility.

Dr. Charles B. Dudley's recent presidential address before the American Society for Testing Materials discussed the causes of failures in engineering. Failures may be ascribed to one or more of the four following causes, viz., to bad material, bad workmanship, bad or faulty design, or to unfair treatment.

Material is bad when it is different from what those who put it in service had a reasonable right to expect it to be. Explanations or excuses for poor materials are the consideration of price; further, the fact that processes of manufacture do not always and every time yield the desired first quality product; finally, the "most pernicious" attempt, so common everywhere on the part of producers, to usurp the legitimate functions of both the consumer and his expert.

With respect to bad workmanship, Dr. Dudley thinks that the piecework system has been somewhat antagonistic to quality of work, though he is unable to suggest a remedy. Dr. Dudley thinks from the indications which he has been able to gather that the increase of efficiency of workmen, following voluntary increases in wages, has been most disappointing. A very pertinent side remark of Dr. Dudley on labor unions is quoted on our first editorial page.

As to faulty design, it is pointed out that the designing engineer cannot always accurately compute the strains to which the whole or parts of the structure will be subjected. "The engineer who makes the design, perhaps more often than any of us, is at the end of his knowledge, and if failure comes, due to defective or faulty design, deserves, in our opinion, more sympathy than any one else involved." Further, the designing engineer is often overruled by those who control expenses.

Finally, as to unfair treatment. A bridge, designed for not over two-thirds the live load which is actually put on it, is unfairly treated. Also, materials entering into a structure may be unfairly treated; if the calculated strains are too high, or, what amounts to the same thing, too low a factor of safety is employed, materials are unfairly used.

Dr. Dudley concluded as follows: "Would not an infusion of genuine conscientiousness into our industrial life bring an amelioration? If a little less energy was expended in the mad race for wealth and a little more zeal manifested in maintaining the rugged virtues of honesty, integrity and fair dealing, would not some of the friction and contention of our present commercial life disappear? We must all live together, and surely harmony is better than contention. There are some things in life of more value than money."

CORRESPONDENCE

Electric Resistivity of Fused Steel.

To the Editor of Electrochemical and Metallurgical Industry:

Sir:—In the table which you published on page 300 of your issue of July, 1909, and forming a part of a communication from me, there are unfortunately four typographical errors and I would be obliged if you would publish this correction of them in your next issue; you will notice that the errors were not in the original copy sent you.

In the second column, third line, the temperature should be 1280 and not 280.

In the third column, second line, the number should be 0.000,200 and not 0.000,000.

In the third column, fourth line, the number should be 0.000,114 and not 6.000,114.

In the fifth column, third line, the figures should be 6,250 and not 6,502.

Philadelphia, Pa. Carl Hering.

[We greatly regret these typographical errors. In view of the importance of the matter, we herewith reproduce again the table, corrected:

	Material.	Temp. C. deg.	Resistivity cm.	Resistivity inch.	Conductivity cm.	Conductivity inch.
1	Fused steel	not given	0.000,140	0.000,055	7,140	18,100
2	Fused steel	not given	0.000,200	0.000,079	5,000	12,700
3	Fused cast iron	1280-1340	0.000,16	0.000,063	6,250	15,900
4	Iron and cast steel	about 1300	0.000,114	0.000,045	8,750	22,200
5	Puddle steel	15 deg.	0.000,014.1	0.000,005.54	71,100	181,000
6	Bessemer steel.	15 deg.	0.000,023.2	0.000,009.16	43,000	109,000
7	Pure copper	15 deg.	0.000,001,687	0.000,000,664	592,800	1,505,000

The reference numbers 1 to 7 designate the origin of the data, for which see page 300 of our last issue. In the table the resistivity units are in terms of the ohm, cb. cm. or the ohm, cb. in. units, and the conductivities in the reciprocal ohm (or mho), cb. cm. or cb. in. units.—Editor.]

The Centering of Great Industries in the New York Metropolitan District.*

BY DR. CHARLES F. MCKENNA.

If on a map of Greater New York and its environs we were to draw a line from the city of Yonkers, on the Hudson, in New York, to the city of Paterson, on the Passaic, in New Jersey and then extend it southerly to the city of Newark, to Elizabeth to Perth Amboy, around Staten Island, thence to and around the easterly boundaries of the Boroughs of Queens and the Bronx to the city of Yonkers again, we should have circumscribed a territory approximately 700 sq. miles in area, whose great natural advantages and acquired advantages for the economical manufacture of the greatest variety of materials have brought about most happy and satisfactory results for commerce and technology.

In this territory will be found located the great sugar refineries of Yonkers, Edgewater, Jersey City, Brooklyn, and Greenpoint; the silk and woolen mills of Paterson, Passaic, and Hoboken; the metal smelting works of Newark, Irvington Perth Amboy, Carteret, Staten Island, Bayonne, and Laurel Hill; the corn works of Shadyside, Newark, Perth Amboy, Bayonne, Staten Island, New York City, Bushwick, and Greenpoint; the jute mills and fiber works of Brooklyn; the linen and cotton thread works of Paterson and Newark; the lead and white lead works and linseed oil plants of Staten Island and Brooklyn; the paint and varnish works of Newark, Jersey City, Long Island City, and Brooklyn; the lard refineries of Guttenberg, Jersey City, and New York City; the cotton-oil refineries of Guttenburg; the great soap works of Babbitt, N. J., and New York and Jersey City and Staten Island; the glue and fertilizer industry of Newark and Barren Island; and, lastly, the great mineral-oil refineries of Brooklyn, Edgewater, Bayonne, Bayway, and Greenpoint.

It has not been my principal view to refer to the other very large manufacturing interests for which the district is famous such as the production of clothing and of the great variety of general articles of wood, leather, metal or whatsoever material, or to the manufacture solely intended for supplying utilities to the district, such as gas-making; I mean rather to consider the great fundamental industries in which raw material is treated in a large way for the supply of the world's markets with staples. Those listed thus make a very impressive array. Some general figures about them make an astonishing showing.

Eighty per cent of the 6,000,000,000 lb. of refined sugar used in the United States is refined here; the concern which refines 80 per cent of the petroleum in the United States has here five of the largest of its 20 refineries, and another concern one refinery; the silk mills of the district, including throwing, weaving and dyeing works, are more than 60 per cent of all in the country and produce more than $60,000,000 worth of goods, and so on through most of the industries which seem almost peculiar to the district, so concentrated is the country's production therein.

The foreign commerce figures of this and certain other large ports are striking.

TOTAL IMPORTS, FISCAL YEAR, 1907.

New York City	$853,696,952
Boston	124,432,977
Philadelphia	79,869,942
Baltimore	37,774,305
San Francisco	54,094,570
New Orleans	46,046,772
All other points	238,505,907
	$1,434,421,425

TOTAL EXPORTS, FISCAL YEAR, 1907.

New York City	$616,270,674
Galveston	236,277,727
New Orleans	169,897,311
Boston	99,820,742
Philadelphia	94,542,966
All other ports	636,908,614
	$1,853,718,034

But the census figures for all manufacturing industries hereabouts also contain some statistical truths of importance.

*Extracts from a paper presented at the Brooklyn meeting of the American Institute of Chemical Engineers. The full paper will be published in the Transactions of the Institute.

INDUSTRIES OF METROPOLITAN DISTRICT.

COMPARATIVE RETURNS FOR 1900 AND 1905 FROM MUNICIPALITIES WITH POPULATIONS EXCEEDING 8000.

	Number of Establishments.		Aggregate Value of Products.	
	1900.	1905.	1900.	1905.
New York City	19,243	20,839	$1,172,870,261	$1,526,523,006
Yonkers	107	105	17,303,690	33,548,088
	19,350	20,944	$1,190,173,951	$1,560,071,094
State of New York	35,957	37,194	$1,891,830,872	$2,488,345,579
Bayonne	63	58	$38,601,429	$60,633,701
Bloomfield	39	33	3,370,924	4,645,483
Elizabeth	141	124	22,861,375	29,300,801
Hackensack	21	23	782,232	1,488,358
Harrison	41	41	6,086,477	8,408,924
Hoboken	194	279	10,483,079	14,077,305
Jersey City	536	628	72,929,690	75,740,934
Kearney	16	11	1,607,002	4,427,904
Montclair	23	19	663,592	621,145
Newark	1573	1600	112,728,045	150,055,227
Orange	74	66	2,995,688	6,150,635
East Orange	22	17	2,086,910	2,326,552
Passaic	70	95	12,804,805	22,782,725
Paterson	487	513	48,502,044	54,673,083
Perth Amboy	47	53	14,061,072	34,800,402
Union	57	77	3,403,136	3,512,451
West Hoboken	65	95	4,769,436	5,947,267
Metropolitan District in New Jersey	3,469	3,732	$358,736,936	$479,592,957
State of New Jersey	6,415	7,010	553,005,684	774,369,025

Summary.

Metropolitan District, New York	19,350	20,944	$1,190,173,951	$1,560,071,094
Metropolitan District, New Jersey	3,501	3,781	361,174,370	483,165,091
Met. District. Total	22,851	24,725	$1,551,348,321	$2,043,236,185
Rest of U. S.	184,711	191,537	$9,859,772,801	$12,758,910,902
Total of United States.	207,562	216,262	$11,411,121,122	$14,802,147,087

From the above table it will be seen that the States of New York and New Jersey, which contain about one-eighth of the population of the United States, produce within their bounds nearly a quarter of the aggregate national manufactures. Of the three and a quarter billions made in these two States about two billions fall to the share of the Metropolitan District, or about one-seventh of the entire production of the United States, while its population may be estimated at about one-twelfth of the total. The importance of the district as a factor in our national industrial economy is thus amply illustrated. With its two-billion annual product of varied manufactures, the Metropolitan District far outstrips the other general manufacturing cities in the country. Chicago being next in importance with one billion dollars; Philadelphia and Camden following with $625,000,000, and Boston with the neighboring cities showing about $360,000,000.

The manufacturing capital in the whole of the United States was, in 1905, about $13,000,000,000, or 86 per cent of the annual product. The proportion shown for the Metropolitan District was about 72 per cent of the annual product. Thus the Metropolitan District gets a larger return on capital invested than the rest of the country.

Cost of Labor.—By the census figures the amount of wages paid in the entire country on the product of $14,802,000,000 in 1905 was $2,611,000,000, or about 18 per cent. A separate figure for the Metropolitan District was about 16 per cent. This again can be laid to high value of machine output.

The author concludes by expressing the belief that the territory thus described and recognized as the great Metropolitan District is destined to become the most interesting technological center in the world and the seat of the most varied and the largest establishments treating raw materials for the production of staples.

Natural Causes for Growth.—It is well for the citizens of the metropolis to understand why these industries have been attracted to it, how they can be held and encouraged to increase, and how others can be induced to settle within the same area.

The location of great industries sometimes move the world almost as much as political and great popular movements. The cotton of Manchester, the iron of Cleveland, the soda of Newcastle in resisting competition of place and of process, by being

firmly rooted, have affected the destinies of England beyond estimation. The fight of Pittsburgh against the Lake district, the South and the seaboard will result, though a strife among brothers, in the absolute domination of the United States in the iron and steel trade of the world; while the contest between the cotton mills of New England against the advancing front of the Southern mills has brought about in the former much attention to detail and in economy, and such application of higher technical skill trained in special schools for that very emergency that the result is the protection of enormous investments, the perfectioning of products and a stop to the loss of trade.

In seeking for natural or historical reasons to explain the industrial development of this region, we will find in the first place that while this fair section of our planet has both hills and plains, it is washed and serrated by a generous supply of waterways, that these in turn are deep and that they terminate in bays of large extent, discharging voluminously into the ocean.

A properly drawn map will also show a great network of rails approaching the center, running along the banks of these waterways, crossing them above, below, connecting and interconnecting. When to these natural advantages we add that of a commanding position as a port of entry, and one where articles of export can be most favorably taken on, we see that these are the overwhelming influences causing the growth. Civic pride directing the mighty forces to co-operate here has not at all been the agency for good that we might imagine—the great city has grown rather in spite of a deficiency of such pride. The historic significance of the early selection of this port for entry by the transoceanic vessel lines, the genius of DeWitt Clinton, the parallel powers of Alexander Hamilton, have frequently been recorded, but notwithstanding the existence of chambers of commerce, boards of trade and merchants' associations, few grand conceptions similar to Clinton's creation of the Erie Canal and Hamilton's foundation of a city on the Passaic and the utilization of the water-powers of that river, or similar to the introduction of the Croton water system into New York City in 1812 have been formed or brought about to completion.

Lack of perception between the States and among numerous municipalities that their interests were so intertwined as to be identical, have hampered great undertakings leading to expansion of manufacturers, and in many ways when these did not operate as inhibiting agents the evils of petty political manouvering did.

The writer proposes to show that if the great Metropolitan District just described could be included in a commercial zone to be covered by treaty in which the community of interest would be thoroughly recognized, for the improvement of waterways, raising of flooded land areas, the erection of docks, increase of water supply, tapping and introduction from a distance large supplies of fuel, gas or electricity, protection of certain areas against land exploitation in order that housing may be sanitary, salubrious and secure for the laboring man; all of these could be brought about without waiting for the haphazard development that comes with the urgency of demand. An enlightened and broad-minded consideration of the rights of the 10,000,000 dwellers to be in this territory ought now to be taken up by those highest in authority and most able to bring about the good.

Let us consider how these great works came to grow. Many of them, such as the sugar business and chemical works, were in the very earliest history of the city used to meet the local demand of their vicinity. The first sugar refiners were the confectioners. The first lard refining was in the slaughter houses. The possibility of shipping by the Erie Canal and the bringing of hard coal by rail and water determined that the refineries, paint works and chemical works could increase, and the supplying of the outside world began. The greatest factor of influence besides those already mentioned was undoubtedly the draining of the Pennsylvania oil fields into this center by means of a pipe line 400 miles in length.

The offensive character of some of these businesses and the necessity for securing large areas of cheaper land than city lots gradually caused the establishment of factories in the meadow lands of the surrounding river valleys, and in many cases the works that had removed to a desolate spot became the center of a small city itself. Then improvements were made in processes which made even some of the most offensive innocuous and not in such wise undesirable.

Sites.—We find now the following situation as regards site and position: The Hudson River from Yonkers down to and opposite Riverside Drive has been taken up for park or ornamental purposes, which will exclude factories in the future. The city generally has such extraordinary demand for its docks for steamship and general city purposes that very little manufacturing will in the future be done immediately on Manhattan Island's waterfront. Brooklyn, Astoria, and a part of the Bronx shore will continue to attract manufacturers. South Brooklyn is particularly advantageously situated, although the land areas are not so large.

Staten Island, from the point of view of deep-water frontage and large inland areas, is an ideal situation and promises to continue the great growth which has been going on for a score of years. Perth Amboy, Bayonne, Elizabeth and Newark are rapidly assuming positions of importance in the establishment of large units of production of manufactures. Jersey City, Hoboken, Weehawken are old-established sites, improved nearly to their limits. Passaic and Paterson are desirable locations for manufacture of articles susceptible of carrying heavier charges for handling and calling for a large force of contented skilled labor.

The meadows skirting the shores of the Hackensack, Newark Bay and Passaic River have been left to the last because we considered it one of the most important of the local areas, and the one which will call in the future for the application of the most farsighted principles for development. These meadows extend from Elizabeth to Hackensack and are of the general width of four miles and are about 18 miles in length. There is an area of 37,000 acres involved. There are 12 important lines of railway crossing them. The improvement by filling and utilizing as solid land this great and almost unused territory is a dream which has fascinated many engineers and economists who see on the one side of it the great metropolitan city and on the other side other large cities growing toward one another until they appear to meet and form another unit which could almost be called a metropolis.

Admitting that one of the great reasons for the development of Manhattan Island was its beautiful situation, washed by swiftly flowing and broad streams on two sides, one finds in these other two rivers, the Hackensack and the Passaic, the promise of great advantage if only the low-lying bordering acres could be properly prepared for industry. Such an improvement was proposed in 1896 (Geological Survey of New Jersey, Report of State Geologist for 1896) by C. C. Vermeule, whose plans included a system of embankment and subsequent removal of the water by pumping.

This has never been carried out on exactly the same plan as proposed by Vermeule, but to some extent certain portions of these meadows have been improved by depositing upon the river mud and sand dredged by hydraulic dredges. The result is that at present an area of several hundred acres has been presented for use, none of which has yet been, however, improved by factory buildings.

The city of Newark interested itself in securing the deepening of the channel in Newark Bay to about the center line of the city. This improvement has just been consummated. The same city is also at work on a project of excavating further channels and a canal system bordered by bulkheads behind which the dredged material will be deposited, thus reclaiming an area of 3000 or 4000 acres.

Fuel and Power.

The great element of advantage to New York in the past has

been its proximity to the anthracite coal fields of eastern Pennsylvania. This valuable fuel was supplied in amounts of extraordinary tonnage and at prices which for a great many years during the early development of manufactures was extremely low. The appearance of the spectra of extinction of its valuable deposits has been one of the elements along with the high labor costs and high freight rates to bring about high prices for this coal delivered in New York City. The price has continued to increase until now steam sizes in large lots are from $2.50 to $3 per ton.

Bituminous coal is coming more and more into use in the outlying parts of this district where smoke consuming may not be so strongly enforced. The prices of this coal are on a par with anthracite. Of both kinds of coal the factory demand on New York Harbor points is about 2,500,000 gross tons annually.

With such fuel charges the cost of steam power would have risen to a damaging level were it not for a coincident improvement in boiler and steam engine practice. The need of large volumes of water for condensing has not been felt by any of the factories located on the tidal streams and bays. In the great railway power houses increased efficiency is being reported, and it seems as if extensive manufacturing establishments ought to acquire whatever of these advantages are not due to regularity of output and steadiness of load. The great losses from imperfect combustion and from unburned coal still continue to be viewed calmly by numbers of managers.

In the future new sources of power will probably be placed at their command, and inasmuch as the largest field for such power will be where manufactures are most concentrated, it is easy to see what could be promised for the district of New York and Newark and the meadows territory lying between.

In the first place we could consider the advantages of power gas. If gas were manufactured for a market at 40 cents, the residuals being produced on a large scale, the consumption for gas engines would warrant the establishment of such a works in a very large unit in the most desirable place in the center of the greatest consuming territory. With the improvements in gas engines, with direct-connected electric generators, the installation of large units intended for the production of power by power-gas is very promising.

Another source of cheaper fuel and power might be sought for in the utilization of the culm banks of the coal mines in the anthracite district, but whether this culm could be carried or floated to New York, or whether it should be gassified near the point of largest supply and the gas piped to New York, does not make such an important question, inasmuch as culm would appear to be an unreliable source and itself rising in value where it is produced.

The advance in producer-gas practice, so well known to you all, points the way clearly for economy to those works managers who can use the product to most advantage, and the adoption of the producer principle to ordinary furnaces promises still further economy of fuel.

Oil as fuel should continue to excite interest even at this point, 400 and 500 miles from the original source of supply of crude oil. The reason for this lies in the fact of an interesting change in the mineral-oil industry coming about through the rapid introduction of power vehicles and power boats. The great demand for gasolene caused by these has brought about such changes in refining that a larger yield of fuel oil is now obtained than formerly. As a consequence its value is as low as 2¼ cents per gallon. The Appalachian, the Lima and the mid-continental fields, with pipe lines to New York, and producing over 50,000,000 bbl. of oil from which from 20 per cent to 25 per cent of fuel oil can be obtained, certainly gives promise of a steadiness of supply, even if the demand should grow great.

The most fascinating promise of new power for this district comes from the hopes of the utilization of certain water-powers. The nearest is the power of the Passic River. It is proposed to establish reservoirs along this stream so that the present flow can be regulated and power obtained over long intervals, but at its best the maximum of power obtainable from this stream is only 12,000 hp, and it is already owned by the Society for the Establishment of Useful Manufactures founded by Alexander Hamilton and controlled by the East Jersey Water Company.

The next most valuable source is to be found in the Delaware River, in New York State; the next after that the water-powers of the upper Hudson River.

In an admirable report of the New York State Water Supply Commission on Water Storage and Power Developments, 1909, these are particularly well described.

In the case of the Delaware water-power, the following appears in the special report of the Engineer, in speaking of the improvement of the Delaware River between Cannonsville and Port Jervis, which could furnish 40,000 to 50,000 constant mechanical horse-power: "This 40,000 to 50,000 continuous hydraulic horse-power will generate, at 95 per cent efficiency of electrical machinery, from 28,500 kw to 36,600 kw, which, distributed under a 50 per cent load factor, and 85 per cent efficiency in transformation and transmission, would deliver in ordinary working hours a maximum of 65,000 to 81,000 electrical hp at the consumer's end."

He says "there is at present no nearby demand for anything like this enormous amount of power. The only adequate market from which returns might be expected is to be found in the thriving manufacturing cities of eastern New Jersey at an average distance of 90 miles. The industrial activity in many of the places within 15 miles of Jersey City, together with the rapid growth in population, and the constant extension of electric railways throughout this district hold out attractive possibilities for the sale of electric power."

But the most promising scheme is the development of the upper Hudson between Troy and Hadley, where horse-power is already developed, but where by systemmatic improvement 196,000 total horse-power could be developed, and as the distance from New York is not at all prohibitive for economical transmission, it would seem as if yet it would materialize. A very powerful agency for bringing this about in the future will be the concurrent improvement in the hydrographic situation which goes with this power improvement, namely, the prevention of floods with all of their accumulated evils.

Given a supply of electrical horse-power in this Metropolitan District under consideration, we could easily see how manufacturing for export of every variety of substances which can now be made the product of the electrolytic vat or the electric furnace will bring still larger industrial industries. And this mode of application of the current is the most promising one for the justification of these distant hydro-electric plants; inasmuch as the demand at an electrometallurgical works is not as exacting as that of an electric railway, because the volume of current demanded in the former permits of long-distance transmission with less line and transformation losses.

If the water-powers of the Passaic, the Delaware, and the Hudson were improved and utilized, thus in and near New York City the combined power supply and present manufacturing development of Niagara Falls, N. Y., and of Lowell, Lawrence and Holyoke, Mass., could be duplicated here and leave many thousands horse-power to spare. The politico-economic effect of such a concentration would be as interesting a study as that of its technological consequences.

Water Supply.

But a great want in the future will always be water supply. There are a few subjects which give the technical manager operating here more concern than this. Shortage of supply, corrosion of boilers, incrustation or large water bills—some or all of these things afflict all but the most favored.

The point of view of the governing authorities in considering water supply is always, of course, first the question of the securing of a potable supply. But the factory manager gives attention also to the question of qualities for his purposes and of cost. A potable water supply would not always be as desirable

for, let us say, a dye house of a bleachery, as one which would not meet the views of the sanitarian for some pathological reason, but which really furnished a good and peculiarly desirable supply. But fortunately most often the most potable water of the large supplies is also equally the most desirable for technical use.

The great bugbear for the large steam users is the cost of water and if this could be reduced the advantage would be considerable and tend to prolong the contest of the steam engine against the gas engine. Water bills of $30,000 and $40,000 a year are not uncommon in the vicinity of New York.

In the district we have under consideration there is a great variety of water supplies.[1] . . .

If the States and the counties recognize no lines of distinction, the following would be the sources to be availed of in the future as a universal system.

Underground Long Island (Queens, Nassau and Suffolk counties):

The Bronx and Byram rivers.
Yonkers wells.
Staten Island wells.
Croton system.
Hudson River at Hyde Park.
Catskill and Esopus system.
Passaic River system.
Rockaway River system.
Hackensack River system.
Pequannock Valley system of Newark.
Perth Amboy wells.

If Brooklyn should draw all that is needed from Long Island; if Staten Island be allowed to draw from New Jersey and in return for this concession New York permit its Catskill line to be tapped at Cornwall for the supply of the territory under consideration, lying on the same sides of the Hudson, all groups and consuming centers and intercommunicating fields would be supplied with the maximum of economy, the minimum of further outlay and the maximum of technical and sanitary purity. But a cry of horror will go up from the New York City taxpayer when he is told of a proposition that contemplates giving advantage to residents of New Jersey of what shall have been acquired by him at a cost beyond his willingness at present to sit down and calculate. But this is just what he should do for his own financial salvation.

The Catskill project has been unwarranted by the facts.[2] . . .

In the prosecution of the Catskill project many difficulties have been met with, and very large additions to the estimated cost are now admittedly necessary. The difficulty of crossing the Hudson River has become increasingly great. The point at which it is now said the crossing is to be made is at Cornwall about 50 miles from the city. This aqueduct will thus have been brought to within 40 miles of the center of the district we are considering, or about 60 miles from Staten Island. To tap it there to go to New Jersey and Staten Island through the trans-Hudson River Valley is to open a market at once for surplus goods whose productions has cost too much to admit of neglecting any sale. . . .

Let the whole territory be considered as a unit of interest. Every factory established in eastern New Jersey is an asset for New York City, and every dweller there a contributor to the wealth of New York City. Then when a population shall have grown up which consumes all of the present supplies and the Catskill supply, we shall still have the Hudson filtered water to draw upon and the Suffolk County supply. For 25 years before that time shall have arrived we will have been drawing a large income from the surplus Catskill water. We shall have been supplying to Staten Island in the most practical way what is difficult to supply across the Narrows, and we shall have been aiding to develop a fringe of New Jersey, which, by almost every right, is practically our own city.

[1] Dr. McKenna gives in his paper a very full review of the various water supplies of the different sections of the metropolitan district. He points out the very serious situation in Staten Island; also almost equally urgent in the consideration of the water supply of the metropolitan district in New Jersey, where some of the water companies are close to the limit of their resources. "A solution of the difficulty for New York in its Staten Island supply and for New Jersey in its eastern cities supply, is to be found in the eradication, by treaty, for this if for no other purpose, of the State line of demarkation."

[2] The reasons for this criticism are given at considerable length in Dr. McKenna's paper. They are chiefly that the estimates of the population and of the per capita consumption were reached in a faulty manner and are both too high; further, that other supplies (for instance, Suffolk County) were available.

Materials Supply.

There are many considerations not touched upon before which point to the correctness of any view which sees a great technical industrial future for the enlarged metropolis. Such would be the excellent supply of material—raw materials—coming by rail and by inland waters and from over seas, and general materials for supplies and repair being quickly obtained. This latter is a source of economy and makes for ease of mind of the factory manager. Such also is the favorable market for skilled and unskilled labor. Another great advantage is the ease of importation and the facilitation of customs business. Manufacturing in bond for export should develop largely in such a district.

We might give a moment's consideration to the observation of how peculiarly certain industries have passed the district by. We have, for instance, practically no iron industry. The last blast furnace, that at Secaucus on the Meadows, went out of blast a few years ago. An old-established rolling mill for structural material at Paterson went into the hands of a receiver about two years ago. Another of pretentious size and new equipment, designed to manufacture open-hearth steel and roll structural shapes, met with a similar fate during the panic. A wire-rod mill making its own open-hearth steel at Astoria several years ago went the same way. Several crucible-steel works, however, are operating and prospering continuously.

But there can be little question, and some good authorities interested in other districts have admitted it, that a blast-furnace plant and steel works for rail and structural shapes could, under proper conditions, be successful in this position. These conditions would appear to be the use of Cuban ore, as well as of Adirondack, Orange County, and New Jersey ores, the manufacture of by-products coke, the utilization of the gases of both coke ovens and blast furnace, and a continued supply of scrap. It is possible that the reduction of the duty on iron ore may help to bring about such a project to realization. At any rate we are almost certain to see with the introduction of electric power the establishment of a considerable number of electrical steel furnaces.

Paper manufacture does not exist, if we except certain paperboard manufactories, and it is not likely to be established. There is no manufacture of cement, and there is not to be any though we may see clinker ground on a large scale and distributed in the surrounding country in bulk.

With this review we may dismiss our subject, but not without expressing a hope of seeing industrial happiness here continue and increase. Because that man is most blessed who is industrious, that city is happiest which has the greatest proportion of contented workers. Our best monuments will not be pleasure palaces, but healthful factories, comfortable homes, cheerful and beautiful buildings, called for by the highest aspirations of a people living by toil, but neither exhausted nor hopeless.

Therefore, to lead this district to its best development is an accomplishment of the highest abilities in constructive statesmanship and practical economics.

Conclusions.—Enough has been said to indicate the truth of the following propositions:

1. The territory described and recognized as the great Metropolitan District is destined to be a most interesting technological center by reason of the establishment within it of the largest works in the world treating raw materials for the production of staples.

2. Its advancement would be more rapid if certain extensive improvements were made under some form of convention eliminating the disadvantages of separate State control.

3. A universal project for water supply is the most important of these improvements.

4. Reclamation of large sunken areas adjacent to deep water to adapt them to normal uses of land is the next most important improvement.

5. Introduction of electric power from the nearest large hydraulic conservation works in both States is an improvement which gives promise of most extraordinary advantages, particularly for electrochemical and electrometallurgical development similar to that at Niagara Falls.

The Estimation of the Temperature of Copper by Means of Optical Pyrometers.

BY G. K. BURGESS.

The experiments here described are a part of a proposed series of determinations of such thermal properties of materials at high temperatures as are of considerable technical interest.

The measurement of the temperature of inaccessible masses of hot metal, whether liquid or solid, is of prime importance to the metallurgist, and it is generally recognized that an optical or radiation pyrometer sighted upon a clear surface of liquid metal, such as iron and copper, indicates too low a temperature if the pyrometer has been calibrated in the usual way in terms of the radiation from an enclosure approximating a black body.* It was in order to furnish the data needed for an approximately correct estimate of the temperature of liquid and solid copper by means of optical pyrometers using monochromatic light and by means of pyrometers using total radiation, that the following experiments were undertaken. Some preliminary observations have also been made on iron, but further work has been postponed until the greater facilities of the new heat laboratory, now in the course of erection, are available. It is also hoped to make similar measurements on aluminium, brass, bronzes, and special steels.

It is a very difficult matter to determine accurately by any method the true temperature of the surface of a mass of metal, although in the case of metals which are good conductors and at the same time poor radiators, as is liquid copper, the uncertainties are reduced to a minimum.

As what is generally desired, however, is not the temperature of the surface of the metal, but of its mass as a whole, this difficulty is of minor importance, since the corrections to the optical pyrometer sighted on the surface may be given so as to reduce its readings to the temperature at some definite region within the mass of the metal.

A complete experimental study of the temperature distribution within a considerable bulk of cooling copper has not as yet been undertaken, but a preliminary attempt is here made to determine, to a degree of accuracy sufficient for most technical needs, the relation between the readings of the two types of radiation pyrometers above mentioned and those of a thermocouple whose junction is placed just beneath the surface of the metal.

Arrangement of Experiments.—The experiments were carried out in a darkened room during September and October, 1908, using an American Gas Furnace Company's No. 3 melting furnace for melting the copper, which was contained in shallow crucibles, both magnesia and graphite of 8 cm inside diameter. With the cover of the furnace removed the gas and air supply could be so regulated that either a clear copper surface or one of oxide could be obtained at will on the liquid copper, the crucible being so set in the furnace that the flames did not play directly on the metal surface in line with the axis of the optical pyrometer. The crucible was set so high in the furnace that radiation from the inside walls of the furnace could not be reflected into the pyrometer, which was pointed at the copper surface at an angle of 25° to 30° deg. with the vertical.

In the case of the rough oxide surface, diffuse reflection from the furnace walls may affect the optical readings, especially if the walls are hotter than the oxide surface. This effect was shown to be small, in the experiments where monochromatic light was used, by changing the height of the crucible in the furnace; but it becomes serious when using the whole spectrum.

When sighting on the pure copper liquid surface, which forms a mirror, there is only specular reflection from bright objects to contend with, and in this case the metal may be at the bottom of a deep furnace and no error can arise from reflection from furnace walls or other incandescent sources unless they can actually be seen in the pyrometer telescope.

In order to measure the true temperature of the layer of copper immediately beneath the surface, the thermocouple was enclosed in a thin porcelain tube bent into the form of a crook in the tip of which was placed the junction of the couple. This method of introducing the thermocouple had the advantage of leaving virtually the whole surface of the copper open to the view of the optical pyrometer, beside eliminating any error in the temperature readings arising from conduction along the thermocouple wires.

The Pyrometers.—The temperature readings of the platinum, platinum-rhodium thermocouple were taken with a Siemens & Halske pyrometer galvanometer of 400 ohms resistance. The optical pyrometer used was of the Holborn & Kurlbaum type, using the Morse principle of disappearing lamp filament, although the results obtained apply equally well for any type of optical instrument using the same red-colored light, such as the Wanner and Féry-Absorption pyrometers, and the Morse Thermogage, when the last is provided with a suitable red glass between the lamp and eye, as in the Holborn-Kurlbaum instrument. There will still be a small correction, however, for the slightly differing reds used in these various instruments. In order to bring out the effects of selective emission in the radiation from copper, measurements were also taken with green glasses in place of the red between the eye and the pyrometer lamp. The total radiation instrument used was a Féry reflecting telescope with gold mirror. It is probable that other total-radiation pyrometers would give results differing slightly from those found here, and even two Féry instruments would probably not give identical results.

All the instruments used were calibrated in terms of the standard temperature scale, on which the melting points of pure zinc, antimony and copper are taken as 419° C., 630.5° C. and 1084° C. respectively. The temperature of the copper freezing point is lowered by the presence of cuprous oxide, and, in a gas furnace, unless a reducing atmosphere is maintained, the copper usually begins to freeze out on cooling at temperatures between 1075° C. and 1080° C. That the thermocouple, whose junction was just beneath the surface of the copper, was really indicating a temperature not far from the true temperature of this free surface of metal, was evidenced by the fact that, as the crust began to form, the thermocouple never read higher than 1080° C. and usually within 5° C. of 1075° C.

Measurements With the Optical Pyrometer.

On Clear Liquid Copper.—To a sufficient degree of accuracy for all practical purposes, the relation between the apparent temperature of the clear surface of the metal free from oxide as given by an optical pyrometer using monochromatic light and the actual temperature of this surface is linear.

For liquid copper possessing a mirror surface free from oxide and haze, we find the following equations to hold for red and green light, respectively:

$$\text{Red light } (\lambda = 0.65\mu) \quad t = 1.515\,r - 359 \qquad (1)$$

$$\text{Green light } (\lambda = 0.55\mu) \quad t = 1.515\,g - 477 \qquad (2)$$

where t is the true temperature centigrade of the copper and

*See "Optical Pyrometry," C. W. Waidner and G. K. Burgess. *Bul. Bureau of Standards*, I, p. 189, 1905; and B. S. Circular No. 7, "Pyrometer Testing and Heat Measurements."

r and g the apparent temperatures given by the optical pyrometer using red and green light, respectively. It will be seen that at the melting point of copper, the pyrometer using red light reads 130° C. too low, and that the apparent temperatures with green light are higher than those with red light by a constant amount over the whole temperature range, namely, by 78° C.

The precision attained in these measurements is shown in Table I, in which the computed temperatures satisfy equations (1) or (2):

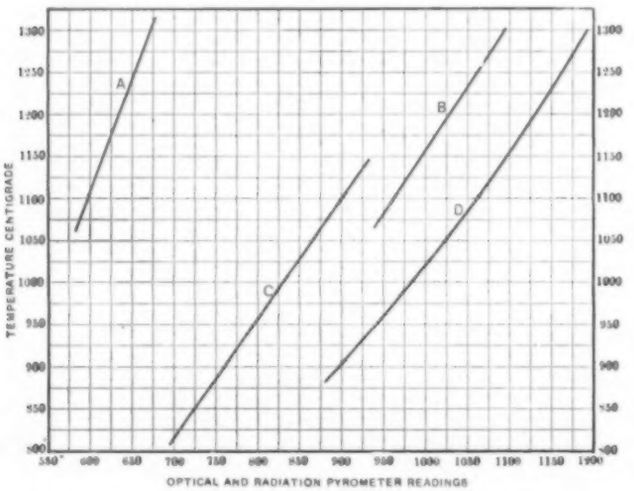


PLATE I.—TOTAL RADIATION PYROMETER CURVES, A AND C. OPTICAL PYROMETER CURVES, B AND D.

(A and C refer to molten copper; A and D to cuprous oxide.)

Table I.—Temperatures of Molten Copper with Optical Pyrometer.

With red glass: λ = 0.65 μ. Temperature centigrade. Computed.	Observed.	Comp.-Obs.	With green glass: λ = 0.55 μ. Temperature centigrade. Computed.	Observed.	Comp.-Obs.
1073° C.	1077° C.	−4	1082° C.	1087° C.	−5
1075	1075	0	1083	1087	−4
1075	1075	0	1092	1101	−9
1075	1081	−6	1107	1104	+3
1077	1075	+2	1115	1119	+4
1085	1085	0	1154	1153	+1
1085	1081	+4	1154	1141	+13
1085	1096	−11	1159	1172	−13
1090	1079	+11	1159	1159	0
1090	1093	−3	1182	1188	−6
1090	1096	−6	1187	1195	−8
1094	1096	−2	a. d. of a single obs. = 6° C.		
1094	1098	−4			
1114	1118	−4			
1123	1117	+4			
1129	1129	0			
1133	1131	+2			
1145	1145	0			
1147	1148	−1			
1157	1155	+2			
1159	1160	−1			
1185	1185	0			
1208	1212	−4			
a. d. of a single obs. = 3° C.			a. d. of a single obs. = 3° C.		

In deducing equations (1) and (2), a slight allowance was made for the fact that the optical readings would tend to be high, due to the slightest impurity on the copper surface.

On Cuprous Oxide.—When the copper freezes or when an oxide coating forms on the liquid, the readings of the optical pyrometer are higher than when sighted on the pure metal. For a thin coating of oxide floating on the liquid the optical pyrometer using red light reads approximately 100 deg. C. higher than when sighted on the clear metal. When green light is used, the change from metal to oxide increases the apparent temperature by only about 35° C., indicating the relatively greater intensity of the green in the light emitted by liquid copper. This greenish appearance persists in incandescent solid copper, as may be seen by adjusting the gas feed, to remove the surface oxidization.

Corrections to Optical Pyrometer Readings.—Table II and plate I give approximately the true temperatures in terms of

Table II.—Temperatures with Optical Pyrometer.

(Red light λ = 0.65 μ.)

Liquid copper: Pyrometer reading.	Liquid copper: Temperature centigrade.	Cuprous oxide: Pyrometer reading.	Cuprous oxide: Temperature centigrade.
950°	1082°	900°	903°
975	1118	950	958
1000	1156	1000°	1020
1025	1193	1050	1087
1050	1231	1100	1159
		1150	1233

the indicated readings of optical pyrometers using red light when sighted upon either the clear copper or the oxide. It will be noticed that for the oxide, the relation between the optical readings and the true temperature is not quite linear. If the liquid surface is hazy, encircled by flames, or only partly oxidized, the optical readings will lie somewhere between the two curves B and D.

Measurements with Total Radiation Pyrometer.

The measurements of surface temperature by this method are much less satisfactory than with the optical pyrometer, since slight changes in the properties of the surface produce a much more marked effect on the readings of an instrument using the whole spectrum, visible and invisible, than of one using only a narrow spectral band.

With the Féry pyrometer used in these experiments the difference in reading at the melting point of copper, when sighted, first, on the clear copper and then on the oxide, was from 275° to 300° C., and the apparent temperature of freezing as given by the Féry instrument sighted on the clear liquid was slightly less than 600° C., instead of 1075° C. or 1080° C., as given by the thermocouple, so that, according to the condition of the copper surface, the corrections to the readings of this instrument lie between 480° and 175° C. at the copper melting point. Even a very slight haze or fog over the copper surface will cause a rise of 25° or 50° in the Féry reading and the presence of flames will change the readings by amounts uncertain both in quantity and direction. The depth of the crucible in the furnace and the effects of radiation from the furnace walls also influence the readings considerably, unless the copper surface is absolutely clear.

The readings of the Féry pyrometer in terms of true temperature, both for the clear copper surface and for the oxide surface, are given in plate 1, lines A and C.

These observations satisfy the following equations:

$$\text{Liquid copper: } t = 3.55\,F - 1018,$$
$$\text{cuprous oxide: } t = 1.41\,F - 169,$$

where t is the true temperature centigrade and F the reading of the Féry pyrometer.

Emissivity of Copper and Cuprous Oxide.

The results obtained from the temperature measurements on liquid copper and cuprous oxide may be expressed in terms of their emissivity, that is, by the ratio of the intensity of radiation, either monochromatic or total, for each of these substances, to the corresponding intensity of radiation of a black body taken as unity.

For monochromatic light, we have, for the emissivity, e_x of a substance:

$$\log e_x = \frac{14500}{\lambda} \log \epsilon \left(\frac{1}{T_x} - \frac{1}{T_b} \right)$$

where the subscript x refers to the substance under investigation and b to the black body, λ is the wave-length of the light used, T is absolute temperature and ϵ the naperian base of logarithms.

For total radiation, the emissivity, E_x, is given by:

$$\log E_x = 4\,(\log T_x - \log T_b).$$

These quantities are given in Table III for both copper and cuprous oxide. Thwing* also finds $E_x = 0.14$ for molten copper with his total radiation pyrometer sighted on a stream of the metal.

*C. B. Thwing: On the Emissivity of Molten Iron and Copper. Phys. Rev. 26, p. 190; 1908.

Table III.—Emissivity of Liquid Copper and of Cuprous Oxide.

Liquid copper				Cuprous oxide			
Temperature centigrade.	ϵ_ν for: λ=.65 μ.	λ=.55 μ.	E_μ.	Temperature centigrade.	ϵ_ν for: λ=.65 μ.	λ=.55 μ.	E_μ.
1075°	0.17	0.47	0.16	800°	..	..	0.66
1125	.15	.38	.15	900	..	..	.60
1175	.14	.32	.15	1000	0.80	..	.56
1225	.13	.28	.14	1100	.60	0.68	.54
1275	..	..	.13	1000	(.49)	(.49)	..

These experiments were carried out with the able assistance of Mr. J. J. Crowe.

BUREAU OF STANDARDS, WASHINGTON, D. C.

The Formation of Silicon Sulphide in the Desulphurisation of Iron.*

BY W. FIELDING.

The object of the work was to investigate the conditions under which ferrosilicon can react with ferrous sulphide and liberate a sulphide of silicon.

In the refining of steel in the electric furnace a very complete desulphurization of the metal can be effected. This action is in practice found to be considerably facilitated by the addition of a charge of ferrosilicon.

Several explanations have been put forward to account for this influence on the removal of sulphur. Some have ascribed it to the high temperature produced during the reduction of the ferrous oxide present by the ferrosilicon. Professor Osann (*Stahl und Eisen*, July 15, 1908; this journal, Vol. VI, page 406, 1908) believes that this removal of iron oxide prevents the back-action between it and calcium sulphide; at the same time a higher temperature is produced by the deoxidation which assists the removal of sulphur as calcium sulphide. At the end of his paper he suggests the possibility of the formation of a gaseous compound, silicon sulphide.

Max Haff (ELECTROCHEMICAL AND METALLURGICAL INDUSTRY, March, 1908, page 96) has previously declared that silicon was produced by heating together sulphides and silicides at a high temperature, but no details were given of his experiments. Silicon sulphides (SiS_2) is described (Hempel and v Haasy) as a solid at ordinary temperatures, which at a red heat sublimes under 60 mm pressure.

In the present work the reaction between ferrosilicon and ferrous sulphide was investigated by heating intimate mixtures of these compounds in a vacuum at known temperatures. The reacting substances were placed in a crucible in the form of a hollow graphite rod, which could be evenly heated by the passage of an electric current. Electrical connection was made with the rod by fitting it in graphite plugs, which in turn were soldered into water-cooled brass tubes to which cables could be attached. (Compare Pring and Hutton, *Trans. Chem Soc.*, 1906, Vol. 89, page 1593, and H. C. Greenwood, *Trans. Chem. Soc.*, 1908, Vol. 93, page 1485.) The rod was surrounded by a water-jacketed Jena glass tube, for experiments in which the rod was heated below 1500° C.; above this temperature a silica tube was employed. The apparatus was made air-tight by luting the ends of the tube with soft wax. Temperature readings were made by means of the Wanner optical pyrometer in those cases in which a glass tube was employed, and changes in pressures were indicated by a mercury gage connected with the tube.

In experiments in which the commercial variety of iron sulphide was used, the mass fused at a temperature of about 930° C., and a vigorous reaction set in with rise of temperature. In later experiments, using pure iron sulphide (free from oxide) no reaction was observed up to about 1300° C., hence the reaction noted in the first case was probably due to reduction of oxide of iron present in the iron sulphide by the ferrosilicon. This explains the sudden rise of temperature noted.

In all the experiments a yellow sublimate began to appear on the walls of the tube at a temperature of 1500° C. On removing this product and treating with water, a rapid effervescence took place, sulphuretted hydrogen being liberated and silica separating. A larger quantity of this product was prepared by placing a mixture (40 gms) of ferrosilicon and ferrous sulphide in a long graphite tube, which was closed at one end and fitted at the other into a porcelain tube to serve as condenser. The graphite tube was then placed in a horizontal carbon-tube furnace, with the porcelain tube projecting outside, and the temperature was raised in stages.

No sublimate was formed until a temperature of 700° C. was reached (the higher temperature required in this case being probably due to the experiment being carried out at atmospheric pressure instead of at reduced pressure as before) when a yellow vapor was evolved, which condensed partly in the tube, the remainder being carried along by the stream of carbon monoxide gas coming off, which on being burned on the end of the tube smelled strongly of sulphur dioxide.

About 4 grams of the product were obtained, which, on analysis, was found to consist of approximately 50 per cent silicon sulphide (assuming the formula to be SiS_2) the remainder being iron sulphide, which had volatilized, silica (obtained from the action of moisture in the air on the silicon sulphide) and a small amount of ferric oxide is a finely divided state. In different experiments products of variable composition were obtained.

The silicon sulphide was estimated by acting on it with water in a Schrotter's apparatus (fitted with a calcium chloride drying tube) and determining the weight of sulphuretted hydrogen evolved. The gas evolved, after being efficiently dried by calcium chloride, was passed into weighed potash bulbs, and the increase of the potash was found to correspond to the lossing weight of the Schrotter's apparatus. The weight of silicon sulphide (SiS_2) corresponding to this weight of sulphuretted hydrogen was then calculated. The product remaining in the apparatus was then treated with dilute sulphuric acid, and the gas evolved driven over into weighed potash bulbs, and the corresponding amount of ferrous sulphide calculated. The estimation of the ferrous sulphide was further confirmed by determining the amount of iron present in the solution, which was found to correspond to the amount of iron sulphide present.

It will be observed that it has not been posssible to fix the identity of the sulphide of silicon present in the product. An attempt was made to prepare the silicon in greater purity by distilling the product in vacuo, but up to 1100° C. no volatilization was observed. No attempt was made at higher temperature, as iron sulphide is also volatile above 1100° C. According to Hempel and v. Haasy silicon sulphide (SiS_2) distils at red heat under 60 mm pressure; this tends towards the conclusion that it is a much less volatile sulphide of silicon which is here produced.

*Paper read before the Faraday Society on June 15.

The Utilization of Low-Grade Fuels in the United States.*

BY DR. O. K. ZWINGENBERGER.

The United States Fuel Testing Plant at St. Louis and its branch at Pittsburgh have certainly rendered a great service to this country in inducing people to pay more attention to the economical utilization of coal. Much talk was heard in the last years that the exhaustion of the fuel supply would be in sight already in some few decades and that a general revolution of both our industrial and public life certainly was to take place. But revolutions do not come suddenly like lightning from heaven; they are all prepared in time, and the revolution to come in industrial life is very well taken care of by the scientific men of the Geological Survey, who are in charge of the fuel testing plant.

The work in the estimation of coals for combustion under the boiler and for utilization in the gas producer has been of great

*A paper read at the Brooklyn meeting of the American Institute of Chemical Engineers, June 24, 1909. Slightly abstracted.

benefit to the development of the industry as is seen by the eagerness with which the gas producer and the gas engine have been taken up in recent time. The gas producer was especially given much attention at St. Louis and Pittsburgh. Nearly all the gas producers in this country are run on anthracite, charcoal and coke, though attempts have been made to construct suction gas producers which can be operated on bituminous coal and lignite.

The United States Geological Survey tried out at St. Louis all kinds of materials down to lignite and peat by boiler tests and gas-producer tests. Though the results were most satisfactory ones, the inducement thus presented to the people in regard to the latter materials were generally overlooked and are not yet made the basis of industrial enterprise, though the future of these materials appear a most promising one at closer inspection.

To low-grade fuels much attention has already been paid for many years in Europe, where, in central Germany and in Scotland, a highly developed industry for the dry distillation of lignite or brown coal and bituminous slate is established. However, those industries were originally not founded to get the fuel contained in this material, but more for the recovery of by-products, and, for instance, in the distillation of brown coal the resulting coke was regarded almost a nuisance as with its disintegrated form difficulties were found in burning it up in the stoves. It was only by the construction of special stoves that the situation of this industry was reversed and the coke was made the main product.

The condition in regard to distribution of the fuel supply abroad is much different from the American conditions, and the people have to look more around to make the best of the raw material available at their location, and therefore many efforts were made to utilize the experience obtained in the distillation of lignite, also in other fields, as, for instance, in the coking of peat.

Peat is a pretty poor stuff in the eyes of many people, not worthy to deserve the least consideration. One cannot deny that there are difficulties on account of the high content of water, which in the crude state goes from 85 to 90 per cent. The drying of this raw material is a serious job on account of the handling of great volumes and the enormous quantities of water which have to be evaporated at the least expense, for which one has to rely mostly on the sun and air. That the drying of peat on a large scale can be done is proved in several instances, and success will be attained as long as carried out with the full attention and severe control of a business man. But this has not always been the case, and especially in many cases this apparently so easy business has been made the object of a stock-jobbing scheme.

That success is possible is shown by the peat coke[1] produced in one of the German works using the process of Mr. Martin Ziegler. It is as hard as any other coke. In its chemical composition it is entirely equal to charcoal, which to replace in nearly all cases it is the most suitable stuff, owing to its hardness. The cost of production of one ton of this coke is about $2 to $2.50. The by-products, which are obtained, are the same as in the distillation of wood, though in somewhat different quantities, and besides these there are some by-products which are obtained in the distillation of brown coal or lignite.

The two materials, lignite and peat, are already extensively used for many years to run gas producers in smelting works, glass factories, pottery works, etc., and though the use of peat is, of course, not such a large one, its use for gas-producer work is very well established by quite a number of plants. This is especially seen from the fact that in the province of Schleswig-Holstein a central gas-power plant is erected to supply electricity to 60 communities lying within a circle of 16 miles, and the whole power necessary is to be furnished by gas coming from gas producers entirely run on peat.

[1] A sample of this peat coke was exhibited at the meeting.

The use of low-grade fuel in the United States is still a very small one, and this fact is due to the distribution of fuel in the United States. In the East there is the anthracite and the bituminius coal; in the West and South the oil, and at many other places there is a good supply of medium coal, anyhow. Moreover, paraffin, lubricating oils, etc., are obtained in the easiest way and in much larger quantities by the distillation of mineral oil, so that it would be senseless to advocate a special coking process for lignite down in Texas, where the by-products of lignite, as paraffin, hydro-carbon oils, etc., would have deadly competitors in the oil and the by-products derived therefrom.

It is, therefore, undisputable that the use of lignite, for instance, in Texas, cannot be developed along lines which have already proved successful at other places, and as the chemical recovery of by-products from lignite is better not attempted, the solution of this problem is either briquetting lignite or gasifying it. For fuel there is always demand, and the gas derived from lignite is as good as that from anthracite, and it can be produced at an extremely low cost, so that it can compete with any material, also water and oil, for power purposes.

What is said about lignite holds also good for peat. States like Texas, Dakota, and Montana, which have enormous supplies of lignite, and the New England States and Minnesota, and Michigan, which have large deposits of peat, are much interested in the question of low-priced power. Owing to the necessity of transporting the power over great distances, cheap production of power is of the utmost importance for the development of those States, and the question whether these States have such a cheap source of power may be answered in the affirmative, as we only have to apply to lignite and peat the experience which is already available from the utilization of these materials at other places.

Here I wish to say some words about a wrong way in which it was very often tried to coke peat or lignite and which never leads to any success, as the resulting coke always will turn out in a disintegrated form. One has to consider that *lignite* in the state it comes from the mine carries a content of water from 25 to 40 per cent, and peat in its natural air-dried state has such a content of 25 per cent. It was very often tried and caused the loss of a great amount of money, to coke peat in a furnace which in its dimensions is pretty near the Hoffman-Otto oven, which is very long, has a height of about 2 yd. and the width of about 20 in.

Now what will take place if one puts a material with such a high content of water into a furnace which, according to its dimensions, is evenly heated all over its surface and the temperature of which is generally pretty high, a temperature of about 1000° C. generally prevailing in the inside? When such a coking chamber is filled the water in the raw material is subjected suddenly to evaporation and this development of steam is so vehement in its power that such a brick of air-dried peat or lignite unfailingly must be blown to pieces.

FIG. 1.—LAYER FORMATION IN COKING CHAMBER.

Furthermore, the material shrinks very much, so that after a certain time the upper part of the coking chamber would show up a hollow space and the heat conduction would be very poor so that the output would be very low in quantity, and a considerable time would be required. After a certain time one has, therefore, to fill in a new charge of raw material, and even this second charge would still leave after a certain time a little hollow space which one has to fill up again. It will then happen that when the lowest layer will be entirely coked, the middle layer will be only in a half finished state, and the upper layer in its first state of carbonization. (Fig. 1.)

This proves clearly enough that a horizontal retort of moderate height hardly will be a convenient apparatus for coking raw material of such qualities as represented by peat and lignite, and the upright retort is then left as the only means to

carry out successfully a coking process for this stuff as it has been used, for instance, for a long time in the distillation of lignite, and the furnace used in this industry was later on adopted and greatly improved by Mr. Martin Ziegler for the distillation of peat. (Fig. 2.)

The special feature of his process is the heating of the retort from outside from two independent fireplaces; the lower one gives the chamber the inside temperature of at least 1000° C., and the upper fire furnishes an inside temperature of about 600° C. As the heating is, anyhow, not carried to the utmost top of the retort, the incoming peat meets by radiation of the heat only

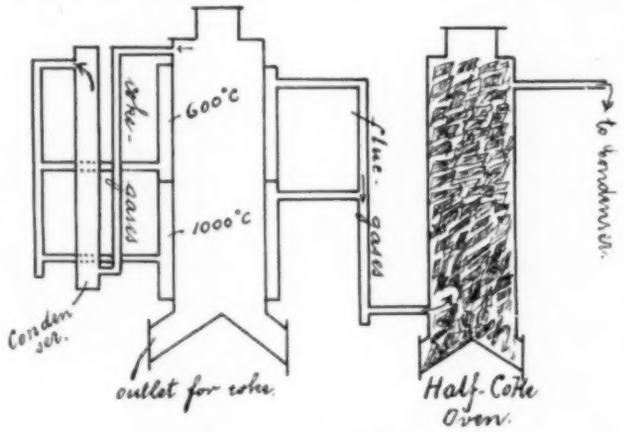


FIG. 2.—ZIEGLER PROCESS.

a moderate temperature. As from the retort, in intervals of one hour, peat coke is drawn off and fresh material is filled in at the top, the material goes down to the bottom, step by step, and passes from the moderate temperature through the medium temperature and at the bottom it is subjected to a high temperature and the effect of such a system is resulting in a material keeping the original structure in which it was introduced to the coke chamber, though, of course, somewhat reduced in size by shrinkage; the coke does not break so easily, and, it may be stated furthermore, that 95 per cent of the material comes out in the form in which it was introduced.

The gases produced in the coking process are passed through a condenser to solidify the tar, etc., and then the retorts are heated from the outside with this gas, and as the supply of air with gas heating can be very accurately regulated, the outgoing flue gases are practically free from oxygen and have a pretty high temperature. Mr. Ziegler has constructed a special furnace which he fills with peat and to which he introduces these flue gases directly and lets them pass over the peat. The temperature of these flue gases is high enough to entirely carbonize the peat and deprive it of the volatile matter and the resulting peat coke is, of course, not so hard as that coming from the retort ovens, but is still hard enough to stand transportation and handling, and to equal average coal in any way.

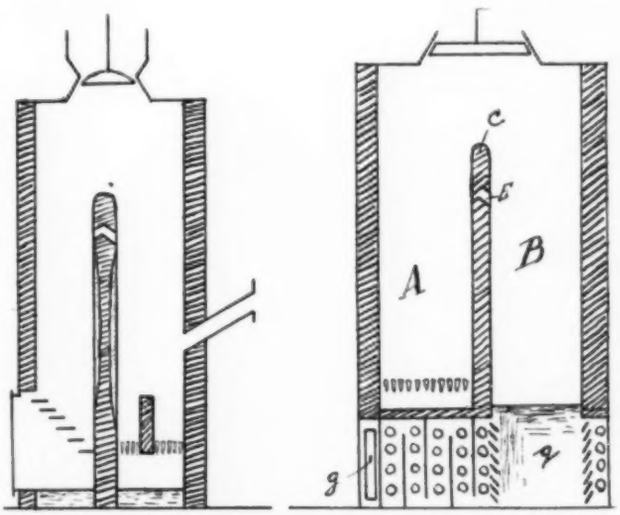
The following table gives the comparative analysis of peat coke, charcoal, and the lower grade of peat coke, which may be called half-coke:

	Peat coke.	Charcoal.	Half-Coke.
C	87.8 per cent	87.6 per cent	73.89 per cent
H	2.0 " "	3.1 " "	3.59 " "
N	1.3 " "	0.4 " "	1.49 " "
O	5.5 " "	4.7 " "	14.52 " "
S	0.3 " "	0.3 " "	0.20 " "
Ash	3.2 " "	0.9 " "	2.50 " "
Water	0.0 " "	3.0 " "	3.80 " "
B.t.u.	14,500-800	14,500	12,100

There is hardly any difference between peat coke and charcoal and the figures for half-coke are good enough to stand the comparison with any good average coal. Now this successful experiment of Mr. Ziegler is of great importance with respect to the rational utilization of lignite and peat under American conditions. By combining a gas producer with a coking chamber, and a material change in the conduct of the gases, we are able to find a convenient form and the results of the combination of gas producer and coking chamber will, for two reasons, still be much better than Mr. Ziegler's half-coke furnace. I refer to a gas producer patented by me, which, with some change, permits the operation of this process. (Fig. 3.)

The gas producer is provided within its combustion chamber with a transverse partition which terminates at some distance below the top. This partition is diminished in thickness at the middle portion and is provided in its upper, thicker portion with transverse channels, and an inclined step grade is arranged at one side of the partition to which air may be supplied under pressure by the means of a supply pipe, the air passes to the fuel through the step grade after the fuel is ignited.

All the gases and tarry substances generated by the burning fuel go through the channels and over the partition into the other space opposite the partition where the fuel is dried and carbonized by the high temperature in the chamber. The gases, the tarry substances, and the steam pass through the high column of glowing fuel, so that the tarry substances are decomposed, while the steam acts on the glowing carbon. The heat generated in the chambers on both sides of the partition by the



FIGS. 3 AND 4.—ZWINGENBERGER GAS PRODUCER. (*g* EXIT FOR GAS, *q* OUTLET FOR COKE.)

combustion of the fuel over the grate is sufficient to reduce the carbon dioxide to carbon monoxide while passing through the glowing zones; the fire-bridge on the plane-grate serves for enlarging the glowing zone.

By this transferring of the tarry matters into permanent gas and the reduction of carbon dioxide into carbon monoxide, the quantity of produced gas must considerably increase, and on account of the greater content of hydrocarbons the heating value of the gas must be greater.

The efficiency of the present gas producer for peat as it is run in Europe is already a very satisfactory one. There is a great number of such gas producers running in Sweden and in Germany. In the latter country there is one, at Scheleken, erected by Mr. Ziegler, which burns up per hour 900 kg, or 1980 lb., of peat, furnishing 2500 cbm gas of 1200 calories, and as for 1 hp 2½ cbm of gas per hour is required this producer would run a gas engine of 1000 hp, but only the smaller part of the gas is used for power purposes and the main part is used in any open-hearth furnace, and on account of the absence of sulphur in the flame, the steel is of an excellent quality.[2] This producer at Scheleken works with recovering the by-products and has a condenser attached to collect the tar and the water; a

[2] This steel plant is now being largely increased. See Transactions of American Peat Society.

great quantity of ammonia is obtained in the form of ammonia sulphate, approaching about 50 per cent of the theoretical value.

The gas producers for lignite and peat all separate tar and sometimes in considerable quantities, according to the size of the producer. This tar is of poor quality and has only a low money value; it is, furthermore, a troublesome nuisance as it is the source of pre-ignitions in the gas engine and of plugging the piston in the cylinder. These troubles are sometimes so obnoxious that they have already caused, in one case, the closing of a 20,000-hp plant operated with lignite.

The condensing apparatus makes the initial cost of the producer relatively high, and the cost to run such a by-product plant in connection with a gas producer is also pretty high since the absorption of ammonia by the sulphuric acid and the concentration of the solution needs good attention and the pumping of sulphuric acid onto the top of the tower is troublesome, too. At remote places, as in Texas, Montana, North Dakota, etc., the question of freight of sulphuric acid is already an item of consideration and another one is the question of labor. At remote places only such apparatus are useful which by their construction and operation guarantee the possibly greatest freedom of disturbances.

It may, therefore, be positively said that only big power plants run on low-grade fuel should work with recovering the by-products and that such plants under 1000 hp to 1500 hp better drop the by-products at all (provided there are not exceptionally favorable local conditions) and adopt a gas producer working up all the fuel to gas by transforming the tar into volatile matter.

A reliable producer transforming all the fuel into gas is certainly the ideal apparatus for places where either lack of time or local conditions do not allow to bother with relatively little quantities of tar and a moderate quantity of ammonia which hardly pays the expenses.

The construction of such a gas producer depends on combining in it the features of coking with that of the gas producer. My gas producer, as described above, is designed on such lines and in its new form allows the production of a much better gas than is generally obtained in the old-style producer.

The change, as shown in Fig. 4, consists in dropping the second grate and in extending the second chamber *B* down to the bottom and making it in this way like a coking furnace, and it furnishes also coke. Whereas in the gas producer the exit for the gases is at the side, the gases leave the new coking furnace by quite another way, for the exit of the gases is now located in the lower part of the partition. The chamber *A* is run as a general gas producer; the gases leave over the partition *C* and through the channels *E* into the chamber *B*, where, in the upper part, the volatile matter of peat or lignite is driven out and the material is going to be carbonized and the heat of the gases is great enough to entirely carbonize the material. It is to be remembered that in the old-style producer the tar is distilled off by the hot up-going gases and is transported by them directly into the scrubber, where it is not sufficiently removed by water. In my construction the part of the chamber *B* directly adjacent to the combustion zone of chamber *A* is so hot that the material is glowing to transform the tar into gas and to reduce CO_2 into CO.

If we let chamber *A* go somewhat hotter, as is usually done with the gas producer, and approach somewhat the Dellwik-Fleischer process to blow in air regardless of a higher result in CO_2 we will get in chamber *A* a great combustion zone of high temperature, and we will have in chamber *B* a temperature of 1000° C. that the action of water on glowing carbon will go on in full extent as in the water gas producer, and besides that the CO_2 will reduce to CO when entering this hot zone. Of course, a part of the hydrocarbons of the volatile matter will be split up by this high temperature.

The special construction of this coking chamber admits of a feature which is generally difficult to combine with a coking process, namely, the cooling of the resulting coke and gas by water with recovery of the heat contained in the glowing coke. There is a system of water tubes; the coke in sliding down will give a considerable part of its heat to the water in the tubes and by partitions the gas is made to pass a certain way along these tubes in order to finally reach the exit. The shutters are for the protection of the water-tubes against pressure, poking, etc. The system of water-tubes is built to form a kind of boiler or evaporator to supply steam to the chamber *A*, if this is to operate as a regular producer.

Now we come to the most interesting question as to the cost of the hp-hour produced from the gas turned out by this coking oven.

In the old-style producers, like that at Scheleken, 1 ton = 2200 lb. of peat gives about 2500 cbm = 87,500 cu. ft. gas of 1200 calories = 135 b.t.u. per 1 cu. ft.

Of such gas a gas engine consumes about 90 cu. ft. for 1 hp-hour, so that we get 87,500 : 90 = 972 hp-hours.

For the gas-producer process we do not need to make fine bricks of about 10 in. length, and 3 in. by 3 in. square, but loose crumbles dried simply on the open air, put in calculation at the price of $1 per ton, will do, so we get, therefore, as to fuel cost for 1 hp-hour 100 : 872 = 0.115 cent. In the Ziegler coking process 1 ton of peat with 25 per cent of water gives in the average 26 per cent gases, weighing 1.104 gram per liter. One

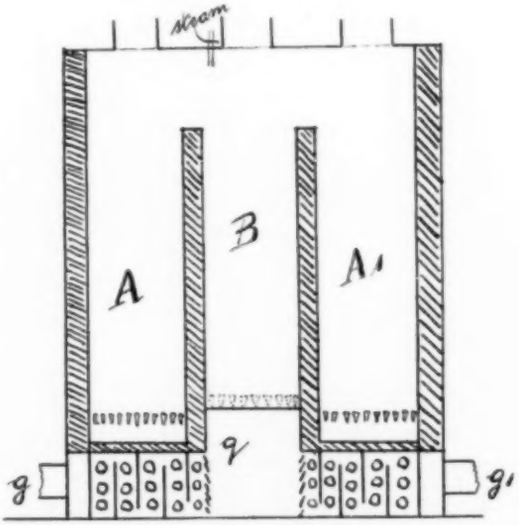


FIG. 5.—MODIFICATION OF FIG. 4.

cbm weighs, therefore, 1.1 kilo, and we get from the total of 260 kilo gas, 260 : 1.1 = 236 cbm gas or 8.100 cu. ft. gas.

Besides the gas there is tar generated, generally between 4 to 6 per cent of the weight of the air-dried peat. This tar I will not put into the figuring, but include it in the 26 per cent gases, thus taking a more unfavorable standpoint than is offered by the actual conditions.

In this new form of coking we can coke in chamber *B* from 2 to 3 tons of peat on 1 ton burned up in chamber *A* and we, therefore, get, besides the gas obtained in *A*, an additional gas of 8.100 × 2 = 16.200 cu. ft. But this gas, as is generated in chamber *B*, is much higher in heating value than this of chamber *A*. It has 320 to 350 b.t.u. per cubic foot, and so we obtain:

Chamber *A* 87,500 cu. ft. gas, each 135 b.t.u., or 11,812,500 b.t.u.; chamber *B*, 16,200 cu. ft. gas, each 320 b.t.u., or 5,184,000 b.t.u. Total, 103,700 cu. ft. = 16,996,500 b.t.u.

This gives 1418 hp; 1 ton of peat burned in chamber *A* costs $1; the gas and tar from chamber *B* is 25 per cent of the applied peat, which costs $2. The total cost of the 1418 hp, as to fuel-cost, amounts to $1.50, or 1 hp-hour at 0.107 cent.

It is evident that the addition of the coke gases to the producer gases is quite a valuable one. I outlined this process for peat because my practical experiences refer me to this material, but the conditions in regard to lignite are so closely

related to those of peat that there will hardly be any change but that given by the different composition of the new material.

The work with lignite is in many regards much better than with peat, as lignite has about 10 per cent more fixed carbon; its content of water is more uniform, and so the relation between the generated steam and the resulting coke is much more favorable to the work with lignite than with peat; with the latter material this point must be carefully studied.

The heating value of the peat gas referred to in my calculations is pretty low, but it is to be considered that it is obtained with a peat varying from 30 to 40 per cent of water. A good producer will, with peat of 25 to 30 per cent water, always furnish a gas of an average heating value of about 150 b.t.u. per cubic foot, and the United States Fuel Testing Plant obtained in one case, with peat from Orlando, Fla., a gas of 170 b.t.u. If we take the additional heating value of the coke gases we will arrive at an average heating value from about 180 to 200 b.t.u. per cubic foot, a figure which never was, and never will be, obtained with anthracite or coke in an average gas producer.

To sum up, we may say that according to European practice (supported in the most successful way by the exhaustive experiments of the United States Fuel Testing Plants at St. Louis and Pittsburgh) the low-grade fuel is very well suitable to furnish an efficient gas for power purposes and to furnish fuel in the form of coke as is equal to the good average coal.

Furthermore, the already extremely low price of 0.115 cents for 1 hp-hour as to fuel cost will be still more favorably modified by the addition of the coking gases; the resulting coke, which will be from 30 to 40 per cent of the peat supplied to chamber *B*, will make up for the by-products as obtained in other processes and is certainly a more desirable by-product as there is always a market for fuel, but not for cheap and bad tar. The project does generally not pay much attention to the recovery of ammonia, but in case chamber *A* is run exclusively on conditions of the gas producer, the temperature in chamber *A* admits of the existence of ammonia and so there will be a way for larger units to consider this point.

The point as outlined here was especially designed for power plants below 1000 hp so as to make the operator (generally an engineer not very familiar with chemical problems) entirely independent of matters which cannot be but troublesome to him.

We are obliged to the United States Geological Survey for a very conservative estimate of the peat supply in the United States, and the highest credit must be given to Prof. Chas. A. Davis, expert in charge of the Peat Division, Geological Survey, Washington, D. C., for giving us reliable figures in regard to that point. All the peat in the United States suitable for coking has a value of 37 billion dollars, and there is still a great amount of stuff which would not do for coking, but would be excellent for gas. As one acre of peat land supplies about 200 tons air-dried peat per foot of depth and a peat bog of some extension furnishes material of low and high ash content a furnace as I outlined will be of great benefit, as with the material high in ash one produces gas in *A* and with that low in ash one produces coke in *B*.

Inoxidation Processes for Protection of Iron and Steel.

By Alfred Sang.

History.—Mill scale, which is mostly composed of black magnetic oxide of iron, forms a non-continuous coating and is a promoter of corrosion. Lavoisier, during his memorable investigation of the composition of water in 1781, discovered the artificial formation of the black oxide (Fe_3O_4) on iron as a continuous impermeable skin and noted its stable properties. Professor Faraday, in 1858, reported on the protective properties of the magnetic oxide formed by the action of the steam in the superheating tubes of H. M. L. "Bustler." Berthier discovered its formation when iron is subjected to the action of highly heated air. Finally, Prof. Frederick S. Barff, of London, being engaged in charring peat, noticed the highly preservative action of this coating, which had formed on the inside of a pipe conveying superheated steam.

Barff Process.—The Barff Process was first made known in a paper read before the Society of Arts in 1876, and another before the Iron and Steel Institute in 1877;[1] it has also been thoroughly treated by B. H. Thwaite.[2] In this process the articles are heated to about 1000° C. (1832° Fahr.) and steam superheated to 1000° Fahr. (538° C.) is injected into the coating chamber.

Bower Process.—Mr. George Bower, of St. Neots (Huntingdonshire) interested himself in this process and tried using air instead of steam; he was not successful, however, until his eldest son, A. S. Bower, conceived the idea of using a producer gas, rich in carbonic oxide, to reduce the red oxide, as obtained by air treatment, either by Barffing or by subjecting the work to acid fumes. A type of furnace well adapted for the purpose was designed, in which the air treatment lasted 40 minutes and the gas treatment 20 minutes, these being repeated alternately four to eight times. Finally the Barff patents were purchased in order to secure a satisfactory first coating of red oxide in a practical manner. The costly experiments undertaken by the Bowers had consumed close on three years.

Bower-Barffing.—The process known as Bower-Barffing consisted in heating the articles to be coated in a closed retort to a temperature of 1600° Fahr (871° C.), superheated steam was then interjected, forming a coating of both the black triferric tetroxide (Fe_3O_4) and the red ferric oxide (Fe_2O_3); this first operation lasted 20 minutes and was followed by the injection during 15 to 25 minutes of carbonic oxide (CO) from a gas producer, which reduced the Fe_2O_3 to Fe_3O_4. These operations could be repeated alternately any number of times until a sufficient depth of oxidation had been obtained. A Bower furnace 12 ft. to 14 ft. long, 4½ ft. wide and 4 ft. deep would treat one to two tons in 24 hours. Three attendants were required night and day for two furnaces.

The Bower-Barffing process was brought to America by Mr. A. S. Bower and introduced to the engineering world in papers read before the American Institue of Mining Engineers[3] and the American Society of Mechanical Engineers.[4] The Hecla Iron Works, of Brooklyn, N. Y., were the first to use it. During his stay in America Mr. Bower was successful in his experiments of using superheated steam during the last one to two hours, and found that the best results were obtained when the steam was at a higher temperature than the articles undergoing treatment.

The process is an expensive one, the cost being said to range from $5 to $20 per ton, and probably more in many cases. The articles come out with a dark-gray appearance, which changes to black on being oiled, and they are somewhat increased in size. Any sand left in castings leaves red traces resembling rust. The surface can be polished or can be given a very fine appearance by brushing with emery and oil, then dipping in a strong solution of potash, and finally cleaning with sawdust, especially if the articles have been polished before treatment.

Enamel will hold on very tenaciously and paint can be applied without trouble. Other points worth noticing are that close packing in the furnace does not prevent action at the points of contact, and the process being one of annealing, the influence on the physical condition of the iron and steel is to be considered before treatment. The coating if too thin will chip off. It is said to be a perfect protection against sea water, and on account of its close adherence when any part of it is broken off the iron only rusts at the point exposed.[5]

[1] *Journal Iron and Steel Institute*, 1877, p. 356.
[2] "On the preservation of iron by its own oxides." *Proc. Inst. Civil Eng.*, Vol. 74 (1883), p. 255.
[3] A. S. Bower, *Transact. Am. Inst. Min. Eng.*, Vol 11 (1882), p. 329.
[4] Geo. W. Maynard, *Transact. Soc. Mech. Eng.*, Vol. 4, p. 351.
[5] "The preservation and ornamentation of iron and steel surfaces," by Geo. Bower, before the Soc'y of Engineers, May 7, 1883, *Transact.*, Vol. 23, p. 59.

The coating resists acid fumes better than does galvanizing, and it is not affected by sulphate of copper. The difference between the coefficient of expansion of the iron and the oxide being only slight, the work will stand almost any degree of heat without injury, but it can neither be bent nor machined and the temper and edges of tools would be destroyed if treated. Wrought iron requires less heat than cast iron. If part of the coating is removed, the exposed parts rust more readily than ordinary iron. The articles treated are weakened, not only to the extent of the iron which has been converted into oxide, but also by the burning out of the cinder in wrought iron, causing what is known as "dryness."

It has been found excellent for pipes used in mines and for conveying mine water, which is high in sulphur and acids; it has also been recommended for boiler tubes, but does not seem to have been adopted for that purpose. The "noble" metals can be deposited from their chlorides on the oxide coating by the Dodé process. An improvement introduced later into American practice, known as the "Wells process," consists in finishing the work at one operation by using steam and carbonic oxide together, instead of applying them alternately. The Bower-Barffing process and the one which follows have been excellently described and discussed by Mr. M. P. Wood.[6]

Gesner Process.—Another process not unlike Bower-Barffing was introduced on a commercial scale some years later by the late Dr. George W. Gesner, of Brooklyn;[7] it is known as the Gesner process. The deposit in this case is said to be a compound of hydrogen, iron and carbon, or as the inventor claimed, a superoxide, plumbago and hydron, the latter being a hydrogen-iron alloy; analysis shows that there is not less than 2 per cent of hydrogen present.

The mode of operation is as follows: The coating retort is kept at a temperature of from 1000° Fahr. to 1200° Fahr. (538° C. to 649° C.) for a period of 20 minutes, after which steam at a low pressure is allowed to act at intervals during 35 minutes; this steam is brought into the retort through a red-hot pipe at the bottom, known as the hydrogen generator; this would imply that the steam is entirely decomposed, but this can hardly be correct as the decomposition of steam commences at 1000° C. to 1200° C. (1832° Fahr. to 2192° Fahr.) and is completed at 3000° C. (5432° Fahr.) only. The last step of the process is to slowly pour in a small quantity of naphtha or other hydrocarbon and allow it to act during 15 minutes; it reduces any red oxide present and carbonates the surface. Finally the heat of the retort is reduced to 800° Fahr (427° C.) and the articles are withdrawn.

Roofing sheets, steam radiators, architectural iron work, tubes and smaller goods were successfully treated by this method. The charge for coating small articles ranged from 4½ cents to 7 cents per pound, and for large pieces in quantities as low as 1 cent per pound. The advantages claimed over Bower-Barffing are that on account of the low heat, articles are not increased in size or bent out of shape, and that there is no need of removing grease or oil before treatment. Articles treated by the Gesner process will take paint, and tables have been published showing that there is no appreciable loss of strength and no reduction of elongation in steel, although there is some in iron. The essential requisite of duplicating results was very difficult at first and large sums were expended in experimental work. There is a plant in operation at South Brooklyn.

In 1897 Dr. Gesner patented[8] the alloy of hydrogen and iron which he described as resisting oxidation and corrosion, being capable of working like iron and being of nearly the same strength, but of somewhat lower specific gravity. The mode of production was to blow hydrogen[9] through iron in a converter, 1000 cu. ft. of hydrogen at 60° was sufficient for 2000 lb. of iron or steel; the temperature of the metal was to be 2800° Fahr., and the depth 15 in.

In 1900 he took out a further patent[9] on the alloy which is formed as a scale by the action of hydrogen on hot iron; the hydrogen was to be produced by the decomposition of steam (producer gas) and the scale was to be crushed, ground and sieved for purposes not specified.

Other Processes.—The process patented by W. Dewees Wood,[10] of McKeesport, Pa., wherein sheet iron was subjected to the action of hydro-carbon vapors or gas and superheated steam within an air-tight and heated chamber, is identical in principle with the Gesner process, which it preceded. Planished iron, as commercially supplied, has a grayish oxidized surface; it is a sort of Russia iron.

There is an old process for oxidizing iron and steel by means of melted saltpeter or niter (nitrate of potassium, (KNO_3), which was greatly improved by Col. A. R. Buffington,[11] of Watervliet Arsenal, in 1884, and may be considered superior to Bower-Barffing wherever high heat would destroy some necessary quality of the articles.

The process may be briefly described as follows: Saltpeter (KNO_3) and black oxide of manganese (manganese dioxide, MnO_2) are heated together in an iron pot; the saltpeter will fuse, and when the heat is such that sawdust thrown on the surface of the dip will ignite, the pieces to be oxidized are put in cold and stirred about, then suspended for five minutes in the fumes over the pot and finally dipped in boiling water to cool and to clean off any saltpeter which may adhere to their surface. The saltpeter must be of good quality or the results will be unsatisfactory. Cast iron takes on a fine bronze color. The oxidization is evidently due to the action of nascent oxygen.

Claudius has proposed[12] a 5 to 6 per cent solution of manganese nitrate for the production of a durable black coating or patina. The articles are dipped and then dried slowly over a fire or gas flame, the non-adherent powder is brushed off and the operation repeated as often as necessary, then rubbed with oil.

It has also been proposed to protect metal articles with a film of sulphide by subjecting them, in a heated state and in the absence of air, to the action of the vapors of sulphur.[13] In the same way a coating of phosphide has been produced by subjecting iron plates to the action of phosphorus at a high temperature.[14] Russia iron, which was long made under a secret process by Russian manufacturers, is a steel having its surface cemented and oxidized by heating it in piles, with carbon in between the sheets; the fact that this coating was mostly Fe_3O_4 was not known until pointed out by Dr. Percy. Many variations of this process have been patented.

A slight flexible coating of black oxide has been given to wire, which was first rusted by means of steam (the rust given by acid fumes being too loose) by heating in a special furnace and dipping in oil.[15] Iron cleaned with nitric acid, then heated and finally dipped in castor or other oil till cold will turn black.[16]

Hydræsfer Process.—Mr. J. J. Bradley, of Brooklyn, who was for years connected with the Gesner process, has developed and operated a somewhat similar process, for which certain advantages are claimed. It requires but one furnace operation, which lasts one hour or less, and the color of the product is a blue-black, equal to the finest Bower-Barffing, and can be brought out by rubbing with whale or other oil. The process, which is patented, owes its name to the use of brass in connection with the partly decomposed steam which is injected into the retort. The metal to be coated is kept at a temperature of about 1100° Fahr. (593° C.).

[6] "Rustless coatings for iron and steel." *Transact. Am. Soc'y Mech. Eng.*, Vol 15 (1894), p. 998; Vol. 16 (1895), pp. 350 and 663; Vol. 18 (1897), p. 252.
[7] See *Scient. Am. Suppl.*, Vol. 26 (1888), p. 10,442; also *Jour. Iron and Steel Inst.*, 1890 (2), p. 850; also *Iron Age*, Vol. 45 (1890), p. 544.
[8] Engl. Pat. No. 9,403 of 1897.
[9] Engl. Pat. No. 11,166 of 1900.
[10] U. S. Patent No. 252,166 of 1882.
[11] *Transact. Am. Soc. Mech. Eng.*, Vol. 6, p. 628.
[12] *Metallarbeiter*, Vol. 24, p. 318.
[13] P. H. Conradson, U. S. Pat. No. 311,294 of 1885.
[14] Eng. Pat. 695 of 1864.
[15] Chas. Platt, *Engineering and Mining Jl.*, 1892 (2), p. 78.
[16] Eng. Pat. No. 16,451 of 1888.

Electric Process.—Iron and steel surfaces have also been oxidized by electrolysis, the first one to attempt it being A. de Meritens."

The bath was one of distilled water at a temperature of from 70° C. to 80° C. (158° Fahr. to 176° Fahr.) and the cathode was made of copper, carbon or iron indifferently, or could be the tank itself; the work, which was preferably polished, was connected as anode; as weak a current as the water would conduct was then applied for two hours or more and the nascent oxygen given off in the presence of the dissociated hydrogen occluded in the metal, produced a film of black magnetic oxide, increasing in depth with the length of treatment.

If the current was too strong, pulverulent rust would be formed, but with the lower-current rust itself would be converted into the black oxide. No permanent deep coating could be formed unless there was hydrogen present in the iron and on this account it was often necessary to first run the article to be treated as the cathode in order that it might absorb hydrogen. This process is evidently the electrical equivalent of the various inoxidation processes already described; all heat processes seem to have their electrical equivalents; it is a natural consequence of the electrical nature of chemical action.

PITTSBURGH, PA.

The Permanent Mold and its Effect on Cast-Iron.*

BY E. A. CUSTER.

In looking over the work done by this and kindred scientific societies, one cannot fail to be impressed with the wonderful advance that has been made in the knowledge their close scientific research has given us, as well as with the logical means they have pointed out in order that this knowledge may bear practical fruit. Day by day the patient, painstaking work is carried on and unselfishly given to the world at large.

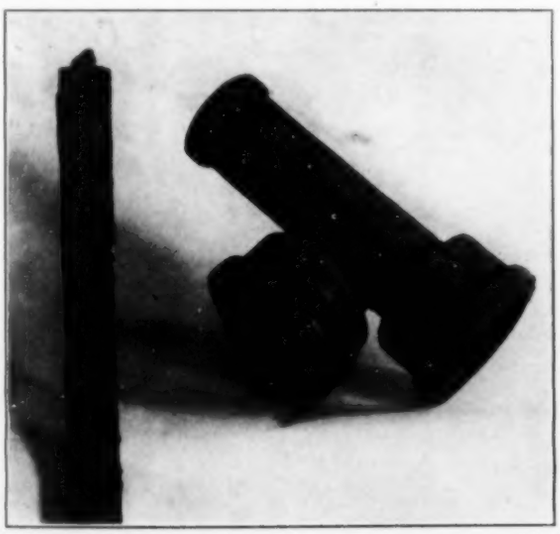


FIG. 1.—CASTINGS WITH SMALL EXCRESCENCES.

It is perhaps natural that the major part of these researches are directed toward steel. The ramifications of this metal are hourly extending, and it is small wonder, in view of what has been accomplished, that the attention of scientific thinkers and investigators has been largely turned to its study. It is at this stage the writer comes forward with a plea for the humble cast iron.

The work noted in this paper covers a limited field, but enough has been learned to give rise to the thought that in this crude material there lurk potentialities which when scientifically investigated may not only enlarge this field, but put an entirely different phase on our understanding of cast iron.

Some four years ago, under the stimulus of a disastrous strike, we started on the hunt for the permanent mold, and finally selected cast iron as the material offering the greater number of advantages and the least number of objections. In the course of our investigations it was noticed that certain of the castings when cool were soft, while others were hard—in fact, chilled white—the hard castings being in an overwhelming majority.

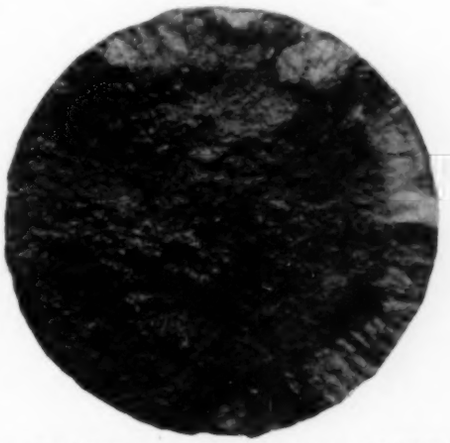
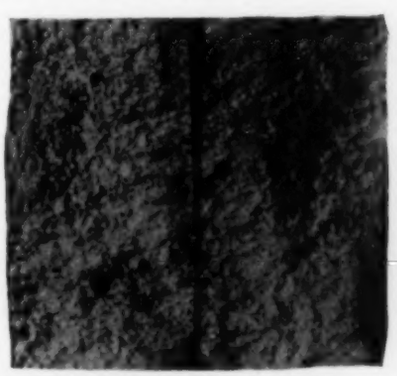


FIG. 2.—FRACTURES OF PARTIALLY CHILLED CAST IRON.

As a remedy we tried various mold coatings of inert materials, but we found that while certain of these coatings gave very good results when applied thickly, yet they slowed up the process. In an effort to gain time the coating was neglected, and it was ascertained that when working at good speed, the major portion of the castings were soft and could be easily machined.

When the coating was entirely discarded and the castings poured and removed from the mold as soon as they had solidified sufficiently to handle, the total production was soft and no hard castings were produced. After some 14,000 or 15,000 castings had been made under every condition that could be obtained in an ordinary foundry, the following bases were established:

(1) Molten cast iron does not chill (using the word "chill" to express hard, white crystals) until after it has solidified.



FIGS. 3 AND 4.—FRACTURES OF CAST IRON. (A) SOFT, (B) HARD.

(2) Chilling molten iron swiftly to the point of solidification, and then allowing it to cool normally, produces a homogeneous metal.

(3) This homogenous metal possesses certain characteristics that are entirely absent when the same molten iron is poured in sand and allowed to cool in the mold.

(4) The chemical constituents of the iron, with the exception of carbon, have little or no effect in modifying these characteristics when gray iron, within ordinary limits, is used.

[17] *Bull. de la Soc. Int. des Elec.*, Vol. 3 (1886), No. 29, p. 230.

*A paper read on June 30 before the American Society for Testing Materials. Mr. Custer is the president of the Tacony Iron Company, Philadelphia.

Inasmuch as all work we have done has been in sections ranging from 2 in. to ⅛ in., it is obvious that the results obtained must be considered in direct comparison with those obtained when these same sections are cast in sand. The casting so low in silicon that it will form white crystals when made in sand will inevitably form the same white crystals if cast in a permanent mold, even though treated by the process outlined above. This applies principally to thin sections; how far this

FIG. 5.—CASTING.

process can affect thick sections depends entirely upon the ability of the investigator to rob the molten mass of its heat.

In support of the first two propositions it may be said that molten cast iron is a solution of carbon in iron, with the addition of silicon, phosphorus, sulphur, manganese and certain impurities—all forming a homogeneous fluid mass. Now, if this mass can be instantly cooled it will still be homogeneous, the different elements not having time to segregate. Instant cooling is clearly impossible, but we find that swiftly chilling the molten mass produces practically the result desired. The molecular action of forming white, hard crystals is only started.

When the casting is removed at a bright, yellow heat, with the

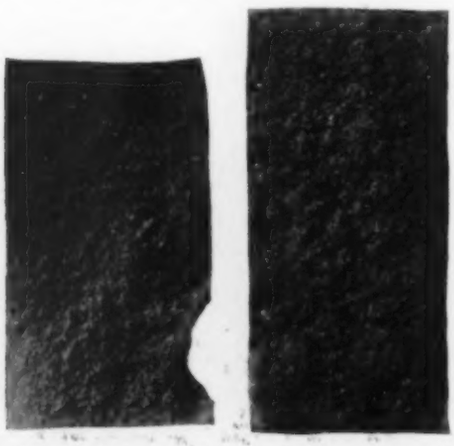


FIG. 6.—FRACTURE OF HIGH-SILICON, LOW-SULPHUR CAST IRON, HARD (LEFT). FIG. 7.—FRACTURE OF LOW-SILICON, HIGH-PHOSPHORUS CAST IRON, HARD (RIGHT).

interior still molten, this molecular action—which is nothing more nor less than a continued closing together of the particles—compresses the molten iron to such an extent that globules of iron exude through the pores and form small excrescences on the surface. This is further shown by the fact that when iron is cast in long bars these bars do not pipe, but the molten iron moves toward the top of the bar, which is partially molten, and forms excrescences at the top. This is exemplified in Fig. 1.

Since the cooling medium, i.e., the iron mold, is removed at the point of solidification, there is no further tendency toward forming larger crystals; furthermore, segregation is completely prevented by reason of the rapidity with which this chilling action is performed. We have tried to reproduce this effect in sand molds, but with no success.

Fig. 2 shows a broken section of a casting one side of which was retained in the mold long enough to produce the white crystals; the other side is soft gray iron. This clearly proves the first proposition.

Fig. 3 is a section from another casting, which was taken from the mold when the point of solidification was reached and was allowed to cool normally.

Fig. 4 shows a section of the same casting taken from the mold at a bright red and quenched in water.

Nos. 2, 3 and 4 were poured from the same ladle of iron. The analysis of this iron is: 2.12 Si, 0.098 S, 0.70 P, 0.38 Mn, 3.49 T.C.

No. 2 is useless as a casting, showing white crystals on one side and dark gray on the other.

No. 3 is clean, soft, easily machined and is as nearly homogeneous as can be shown by any test we can devise. It has a dark gray fracture, machines cleanly, the chips being free from fine dust, and does not show the usual hard scale on the exterior. When heated to a bright red or yellow heat and

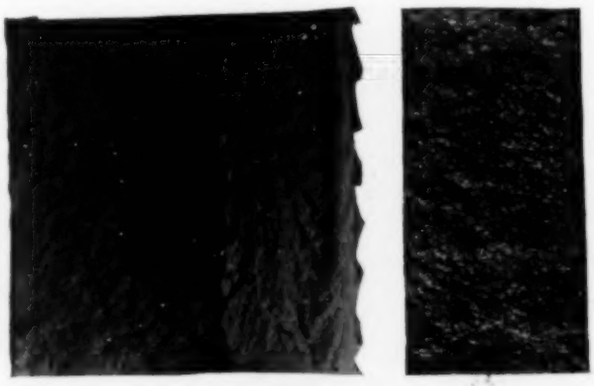


FIG. 8.—FRACTURE OF FILE AND HARDENED CAST IRON (LEFT).
FIG. 9.—FRACTURE OF ORDINARY CAST IRON (RIGHT).

quenched in cold water it has a very light-gray fracture and is as hard as tempered tool steel. When used as a cutting tool it will outlast any ordinary high-carbon steel. Bring it in contact with a working dynamo after hardening, it becomes a permanent magnet.

It does not possess the disadvantage of increasing in bulk when repeatedly heated and cooled. This is illustrated by Fig. 5—a casting that has a distortion of but 0.002 of an inch after being brought to a bright red heat and quenched in cold water, the operation being repeated 10 times. Once having imparted to the iron the properties enumerated above, it is impossible to remove them except by remelting. If No. 3 be held in a bright flame until metal drips from the end, the remaining iron will be unchanged in every particular, with the exception of a slight coating of oxide.

Fig. 4 shows a light-gray fracture, and is an exact duplicate of No. 3 hardened. When heated to the temperature at which it was hardened and allowed to cool normally, it reverts to the characteristics of No. 3. This heat need not be long continued; the mere heating to the proper temperature is sufficient to accomplish the result.

Figs. 6 and 7 are from the same mold. The analyses: No. 6: 2.94 Si, 0.032 S, 0.028 P, 0.38 Mn, 3.08 T.C.; No. 7: 1.75 Si, 0.07 S, 1.42 P, 0.41 Mn, 3.22 T.C.

These present precisely the same phenomena as Nos. 3 and 4, so far as any tests applied will show.

It would seem, from the analyses of the treated samples, that the peculiar properties observed are entirely independent of whether the silicon, sulphur or phosphorus is high or low, at least within the limits noted. It is immaterial whether the silicon is 1.75 or 3 per cent, the sulphur 0.02 or 0.12 per cent, or the phosphorus 1.50 or 0.03 per cent; in any event the same practical result is obtained if the procedure outlined is correctly carried out. In no respect have we been able to duplicate these results when the same iron was poured into sand molds of like dimensions.

The logical explanation of this hardening property is that the molecular action which produces a homogeneous metal by chilling molten iron to the point of solidification, is again the medium of producing the extreme hardness. The first chilling brings the molecules to what might be termed a receptive position. Removing the chilling medium holds this position, and as the temperature falls the molecular position becomes permanent.

If at the receptive point the casting be quenched in cold water, the great unmeasurable force of heat expansion and contraction is brought into play. No one knows how many tons per square inch is exerted when molten iron cools. This force is always greater than the tensile strength of the material under treatment. If, now, the semi-solid iron be subjected to this presumably enormous force exerted through the mold, swiftly robbing it of its heat, it probably follows that the molecules are crushed together with an enormous pressure, and an extremely dense structure results. If the casting be quenched in oil, there is no hardening effect; it remains soft. If thrown into boiling water it cracks into pieces.

Fig. 8 is the fracture of an ordinary forged and hardened steel file placed alongside of hardened cast iron, in this case Fig. 4. The analyses:

File .. ..0.19 Si, 0.022 S, 0.019 P, 0.25 Mn, 1.28 T. C.
Cast iron ....2.12 Si, 0.098 S, 0.70 P, 0.38 Mn, 3.49 T. C.

This photograph shows very clearly the coarse grain of the cast iron and the metal flow of the steel file, yet the cast iron is the harder metal.

Fig. 9 gives a very good idea of the difference between casting in sand and in a permanent mold. This fracture is of the same iron that was used for 2, 3, and 4, and was cast in a green-sand mold and allowed to cool normally. Figs. 10, 13 and 20 are microphotographs of Figs. 3, 4 and 9, and present a very fair field for discussion. They were etched with picric acid and each given a magnification of 104 diameters. The fracture photographs are given a magnification of 2½ diameters.

In this work carbon plays a large part, although it does not seem to have the same effect as when iron is cast in sand. A few notes on this phase may be interesting.

Since all the carbon in molten iron is in solution, and exists in the combined form, then, if molten iron be instantly cooled to 1000 deg. Fahr., all the carbon will be held in the combined form—there will be no free carbon. If, however, it be instantly cooled to the point at which the iron sets, and then allowed to cool normally, the carbon will be in the combined form at the time of setting, but will change to the free form as the cooling progresses. This formation of free carbon is very rapid; the major portion present in the casting is formed within a few seconds after it is taken from the mold. The analyses below give a very fair idea of this action, the pieces in question being 6 in. x 1¼ in. x ½ in.:

	C. C.	F. C.	Sil.
Cast in sand and cooled normally.....	.21	2.93	2.61
Taken from permanent mold at bright yellow and quenched	1.50	1.52	2.61
Taken from permanent mold at bright red and quenched	.49	2.61	2.61

It will be seen from this that two-thirds of the combined carbon has been changed in the few seconds required to cool from a bright yellow to the bright red. The free carbon in all these castings is not in the form of graphitic carbon, as we usually see it in ordinary cast iron, but partakes more of the character of annealing carbon, as exhibited in a malleable casting.

Here we have an iron containing 2.61 silicon and 2.50 free carbon that possesses the property of taking a temper equal to tool steel, and this without the least indication of what is generally termed "chill."

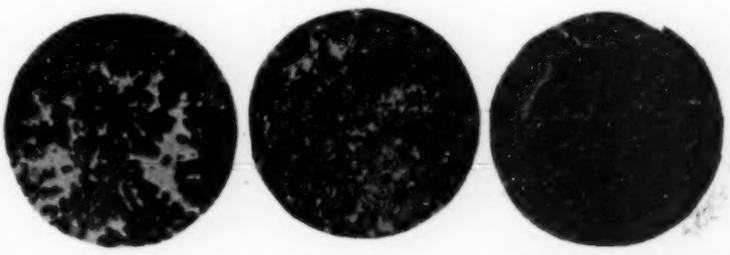


Fig. 10x104. Fig. 11x30. Fig. 12x30. (Oblique light)

FIGS. 10 TO 12.—IRON CAST IN PERMANENT MOLD. (SOFT, SAME AS FIG. 3.)

At this writing, the tensile strength is under investigation. The scope of this research is very large, and many elements must be taken into consideration. Our results so far indicate that cast iron, when chilled in a permanent mold to the point of setting and then cooled normally, is greatly increased in tensile strength, and that this strength does not materially vary within the chemical range of ordinary foundry iron.

The thickness of the section and the initial heat of the casting have the most influence in determining the ultimate strength, and these variations call for an extended consideration.

Heretofore cast iron has had a rather poor reputation, being generally unstable and yielding reluctantly to any treatment that would tend to improve the quality. The permanent mold has done valuable service in demonstrating that the simplest of simple heat treatments endows it with characteristics that entitle it to a very large portion of the consideration that has hitherto been enjoyed by wrought iron and steel. One hardly dare say that the ultimate possibilities of this metal have been reached, nor can it be considered in the light of an unstable and refractory medium. On the contrary, it answers readily and surely to the proper treatment. The field is wide, and gives promise of much that would place cast iron on a far higher plane than it occupies to-day.

Fig. 13x104. Fig. 14x104. Fig. 15x104. Fig. 16x30. (Oblique light)

FIGS. 13 TO 16.—IRON CAST IN PERMANENT MOLD. (HARD, SAME AS FIG. 4.)

I wish to acknowledge the keen interest and self-sacrificing help of Mr. Robert A. Pitman, without whose devoted work much of what has been accomplished would have been lost.

The Generation of Producer Gas.

By Oskar Nagel, Ph.D.

The producer is a simple and efficient apparatus for the manufacture of a cheap industrial gas. Other important advantages of this process are: smokeless combustion of great uniformity, exact regulability of the fire and heat, and the attainment of very high temperatures by preheating the air of gasification and combustion. By working with an excess of air or gas, respectively, an oxidizing or reducing flame is produced. Finally the combination of the various fireplaces into one central station and the saving effected in the cost of transportation of fuel and ashes are factors which should by no means be underestimated.

Our solid fuels contain besides the free carbon also carbon which is combined with hydrogen and oxygen. These compounds form the bituminous or volatile components of the fuels. They amount in wood up to 82 per cent of the total combustible matter; in peat to 60 to 65 per cent; in lignite to 55 per cent; in bituminous coal to 45 per cent or less, and in anthracite to 5 per cent or less.

FIG. 17 X 104.—IRON CAST IN PERMANENT MOLD. (HARD, SAME AS FIG. 6.)

If fuel is heated under exclusion of air, the volatile matters are separated, i.e., the coal is being "degasified." In this process hydrocarbons, hydrogen and also carbon monoxide, carbon dioxide and water are formed. The latter increases with the moisture content of the fuel and escapes during the destructive distillation (degasification). The residue—pure carbon and ash—is called coke, charcoal or peat coal.

If the destructive distillation is carried on at high temperature, as, for instance, in gas works and coking plants, a strongly illuminating gas and liquid tar are formed. At low temperatures the quantity of hydrocarbons is larger, the illuminating gas and hydrogen decrease considerably, the tar gets thick, and, with lignite and peat, also paraffine is produced. The destructive distillation at low temperature also occurs—to the disgust of the manufacturers—in the generation of producer gas.

The generation of producer gas is based upon "gasification," i.e., the transformation of the free carbon of the fuel into carbon monoxide, and it is easily understood that for this process a fuel containing the largest amount of carbon and the smallest amount of volatile matters will be most desirable. Such fuels as anthracite, charcoal and coke, however, though easily transformed into a gas free of tar, are too expensive to be used in the big industries, which are forced to use bituminous coal, wood and lignite.

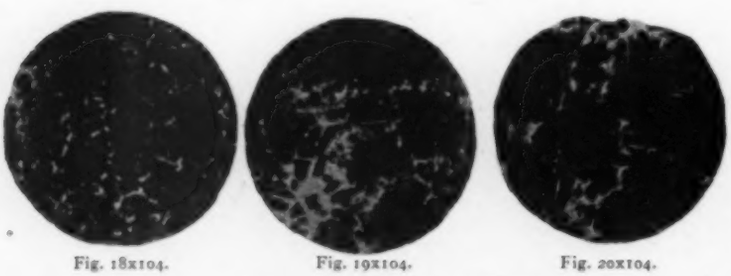


Fig. 18x104. Fig. 19x104. Fig. 20x104.

FIG. 18 TO 20.—IRON CAST IN PERMANENT MOLD. (HARD, SAME AS FIG. 7.)

In small producer plants, especially in connection with gas-power plants, the higher price of anthracite is outweighed by its greater convenience. But even here conditions are changing and the use of bituminous fuels is being slowly but surely introduced.

The gasification of the carbon in the producer is effected in such a manner that the carbon is first burned to carbon dioxide, the latter being then reduced to carbon monoxide by contact with additional carbon. Hence, carbon monoxide is the essential principal of producer gas.

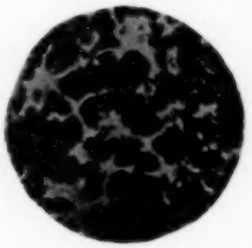


FIG. 21 X 104.—SAME IRON AS NO. 3, BUT CAST IN SAND. SEE FIG. 9.

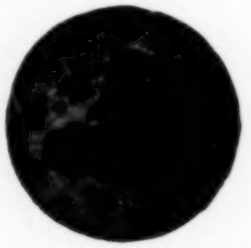


FIG. 22 X 104.—FRAGMENT FROM LARGE CASTING.

The perfect reduction of dioxide to monoxide takes place, theoretically, at a minimum temperature of 1000° C., which is easily produced by combustion to carbon dioxide. At lower temperatures part of the dioxide is not reduced, the formation of the monoxide stopping entirely at about 450° C.

In order to effect the reduction, a high fuel bed is used and less air admitted than would be necessary for complete combustion. The formation of carbon monoxide caused by too high a layer of fuel is of frequent occurrence in ordinary fireplaces and means a considerable loss. It is also known that in direct firing a considerable excess of air has to be admitted if the formation of carbon monoxide is to be avoided.

The height of the fuel bed in producers necessary for complete reduction varies with the quality of the fuels used. Dusty fuels require less height than coarse, loose, fuels. The proper height for 1-in. coke is 30 in.; for 1½-in. coke, 45 in.; for 2¼-in. coke, 72 in.; for ¾-in. bituminous coal, 22 in. are sufficient; for run of mine, 60 in. to 80 in.

This fact shows that it is of advantage to use fuel of uniform size in the producer. Coarse pieces of dust interfere with the uniformity of the gas production and allow the formation of holes, i.e., vertical channels in the fuel bed, so that a part of the air admitted to the producer goes through unchanged, simply deterioriating the gas. However, the low price of run-of-mine coal necessitates its application in industrial gas producers whereby the prevention of hole-formation by means of poking bocomes imperative.

With bituminous fuels too high a fuel layer is not to be used, as this causes an increased formation of tar and soot, for the volatile matters and the moisture escape from the higher zones before the fuel reaches the incandescent zone of reduction. The higher the temperature of the upper layers, the thinner will be the tar produced and the more hydrogen and methane will be found in the gas. The two latter components increase the thermal efficiency, but the former, together with the soot, are disagreeable impurities of the gas, more so if the gas is cooled before its use.

This is always the case where the producers are not built right at the furnaces in which the gas is to be burned. On the other hand the separation of the tar, which has a certain thermal efficiency, and the cooling of the gas involve always a loss. Experiments have lately been made to utilize the tarry components of the producer gas or to decrease the quantity of tar formed. It is known that tar, if drawn through incandescent coal, is transformed into permanent gases (hydrogen, methane, etc.).

As stated above, a temperature of not less than 1000 deg. C. is required for complete formation of carbon monoxide. If considerably higher temperatures are applied, the disadvantages will be found to outweigh the advantages, as by such high

temperatures the fire-brick lining is rapidly destroyed and the ashes of the fuel always obtained as molten slag.

Such slag formations occur with various grades of fuels, depending upon the composition of the ash, at higher or lower temperatures. In the latter case it can only be avoided at the expense of the gas production. Here the addition of water to the gasifying air is a simple remedy, which, at the same time, increases the thermal value of the gas and the efficiency of the producer, simultaneously cooling the grades of the producer.

Incandescent coal decomposes water into its elements. The hydrogen formed enriches the gas and the oxygen combines with the carbon to carbon dioxide or monoxide according to the prevailing temperature. The formation of monoxide by the decomposition of water is most complete at a temperature of 1000 deg. C., while at lower temperatures more and more carbon dioxide is produced. In practice, however, it is impossible to decompose all the water contained in the gasifying air. One part goes always unchanged through the producer and increases the moisture content of the gas. If this moisture is present in the gas during its combustion it has a heat-consuming effect and decreases the temperature of combustion.

Hence, no water is to be added for the gasification of fuels rich in water, and some fuels require even drying, if with the gas produced a somewhat high temperature is to be reached. It is also evident that the temperature of the gas leaving the producer decreases with the temperature of the producer and with the increasing amount of heat which is disposible for degasification and evaporation.

If, for instance, in the gasification of dry bituminous coal the temperature of the gas leaving the producer is 600 deg. C. to 800 deg. C., a temperature of only 400 deg. C. to 500 deg. C. will be observed if water is added. This shows that by addition of water less heat is lost by the cooling of the gases, the loss by radiation being also simultaneously decreased.

Of great importance is the question: How much water may be advantageously added? Fuels with a large percentage of volatile matters can stand only a small addition of water, as, already during their degasification, much water is formed; i.e., much heat is lost. If such fuel is also very moist, the result may be a non-combustible fuel gas, if the gas is not dried before being used by cooling, whereby a large part of the water may be removed by condensation.

The amount of water added must be regulated so that the walls of the producer do not suffer by the heat and that, as much as possible, the formation of liquid slag is avoided.

In gasifying pure carbon 1 kg of water may be added to 4.5 cbm of cold gasifying air without causing any loss of heat and as for gasifying 1 kg of carbon about 4.5 cbm of air are required, the upper limit of the addition of water is about 1 kg to 1 kg of carbon.

If the air of combustion and the water added are preheated the quantity of the latter may be increased and may reach at 550 deg. C. double the amount mentioned above. This explains why in practical gasification of coke, which is practically pure carbon, 300 to 400 grams of water are added per cubic meter of air if a gas rich in hydrogen is to be produced.

In gasifying bituminous coal for the production of a gas not too rich in hydrogen, 150 to 200 grams of water are taken per cubic meter of air. From a theoretical point of view, however, a somewhat larger addition of water is nearly harmless, so far as the utilization of the fuel is concerned. It is true that in such a case a larger quantity of carbon dioxide will remain unreduced, but with the increased quantity of decomposed water, also more pure oxygen will get into the producer. Hence, less gasifying air is required, which means a decrease of the nitrogen content of the gas produced.

The composition of producer gas is varying a great deal. Under normal conditions, if a good grade of fuel is used and the operation properly carried out, the gas will contain about 25 per cent of carbon monoxide. If the producer gets very hot, caused by the total or nearly total absence of water, the content on carbon monoxide may be up to 30-31 per cent.

The second combustible component of producer gas is hydrogen, varying in quantity between 8 to 14 per cent. However, the hydrogen content may be even higher or lower, depending upon the moisture of the gasifying air and other conditions. Some factory managers are afraid of too high a content on hydrogen and believe that it does harm to the firebrick and affects the finished product disadvantageously.

So, however, continued operations with producer gas from peat, which is rich in hydrogen, have been and are being carried out successfully; the harm—if any—done must be due to some other cause, probably to the moisture of the gas, which causes decomposition of and recomposition to water, thereby effecting numerous disagreeable complications. Accordingly a gas rich in hydrogen would have to behave differently when cooled (dried) before its use or when used hot.

That the hydrogen cannot be the only cause of the above-mentioned complications (sudden rise of temperature) is shown by the fact that carbon monoxide in combustion, though not yielding as many thermal units as hydrogen, produces a higher temperature. Hence, a gas, which on account of its high content on hydrogen, has a higher thermal value as compared with others, may be equivalent to the latter, as far as the temperature of combustion is concerned.

There is a certain relation between the percentage of carbon dioxide and the percentage of carbon monoxide and hydrogen. That it is not always of advantage to get a gas with the lowest possible content of carbon dioxide we can see from the fact that at dry gasification, where very little dioxide is formed, the efficiency of the producer is much lower, as with a large addition of water.

On the other hand, the content on dioxide is also influenced by the nature of the fuel, as with low melting slag the temperature must be kept so low that the complete transformation of dioxide into monoxide is prevented. Some grades of coal, therefore, will only difficultly be gasified at reasonable economy if the formation of slag is not taken into consideration and if the producers are not constructed to suit these conditions. As a rule the carbon dioxide should not go above 3 or 4 per cent.

The methane gets into the producer gas from the products of decomposition of the volatile matters. The quantity of methane varies from 1 to 3 per cent and depends upon the temperature of degasification. The heavier hydrocarbons are also sometimes found in traces if the temperature of degasification is very high.

If the tarry compounds of the gas are decomposed in the producer, the composition of the gas is changed, the percentage of carbon dioxide and hydrogen is decreased, of the monoxide increased. As the hydrocarbons have a high thermal value their presence is desirable, especially if high temperatures are to be reached.

Some oxygen is also generally present in producer gas. Leaks and holes in the fire are mostly the causes of its presence. The rest of the gas is nitrogen, which, at dry gasification amounts to 60 per cent, at moist gasification to about 50 per cent.

The **International Acheson Graphite Company** is enlarging the output capacity of its branch works in Niagara Falls, Ont. This company has for many years operated a Canadian branch with facilities far in excess of the demands of the Canadian trade. It, however, recognizes in the hydro-electric and metallurgical development now so active throughout the Dominion and the new trade spirit and energy everywhere present throughout Canada an indication of additional industrial enterprise, and it is to meet the prospective demand for electrodes, etc., likely to be created by the new conditions that it is increasing the size and output capacity of its plant in Niagara Falls, Ont. A new furnace room, providing for a 1000-hp unit is being built, and on completion the new furnace installation will be placed in operation.

Furnace Electrode Losses.

By C. A. Hansen.

Previous work (*Proc. Am. Electrochem. Soc.*, 1909; also June issue of this journal, p. 270) indicated that when water-cooled graphite electrodes were used in the Acheson resistance type of furnace, increasing the thickness of the wall through which the electrodes pass, brought about a decrease in the electrode losses.

The explanation is, of course, that the heat conduction loss is greater than the C^2R loss in a short electrode, and since the

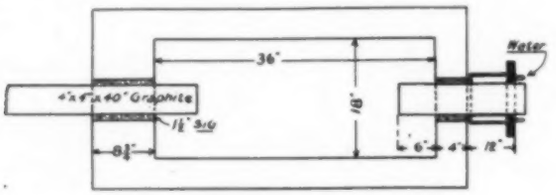


FIG. 1.—DESIGN OF ELECTRIC FURNACE.

heat conduction loss is inversely proportional and the C^2R loss directly proportional to the length of conductor, the sum of the two losses will be less for the longer electrode. There are, of course, limits both practical and theoretical to the extent to which this generalization can be carried.

As regards the practical side, we cannot purchase graphite electrodes greater than 40 in. in length, and while the 6-in. and 8-in. electrodes can be very satisfactorily joined together to give greater lengths, the smaller sizes, similarly joined, are not so satisfactory for ordinary furnace work. As regards the theoretical side, it is sufficient to say that an infinitely long electrode would have an infinite C^2R loss, and even though the heat conduction loss were zero, the sum would still be an infinite quantity.

This paper concerns a few experiments made with a view to determining the effect of electrode length on the electrode loss.

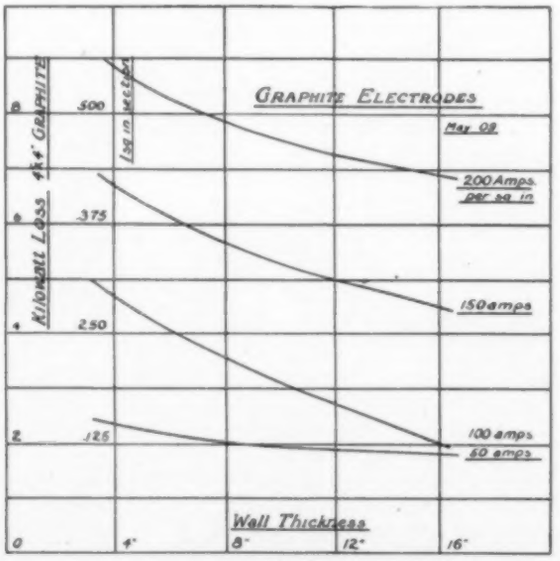


FIG. 2.—CURVES OF ELECTRODE LOSSES.

Apparatus and Procedure.

Two small furnaces, such as shown in Fig. 1, were built. Each had inside dimensions of 18 in. x 18 in. x 36 in., with the four end walls respectively 4 in., 8¾ in., 13 in. and 15½ in. in thickness. The electrodes were 4 in. x 4 in. in section, projected 6 in. into the furnace, and were water-cooled. The water jackets were 12 in. long and were attached to the electrodes over the 12 in. immediately outside the furnace walls. (See Fig. 1.)

Current was measured by means of a 50 to 1 current transformer and Thomson inclined coil ammeter.

Electrode loss was taken from the cooling water, temperature being read on thermometers inserted in the outlet tubes and rate of flow by timing the filling of a 1000 cc. graduate with a stop-watch.

The two furnaces were charged with cracked carbon and they were joined in series so that all the electrodes would have exactly the same current going through them at any moment.

The intention was to make all comparisons with as nearly a constant difference in temperature between hot and cold ends of electrode as was possible, and to keep this temperature difference high, say, 2500 deg. to 3000 deg. C.

To this end, 600 kw-hours were absorbed in the two furnaces during a period of 2½ hours. The furnaces were then permitted to stand for 1½ hours before readings were taken, so that the heat stored up in the electrodes by the high currents previously used would not affect the results. A lower voltage (135) was then impressed and the following readings taken:

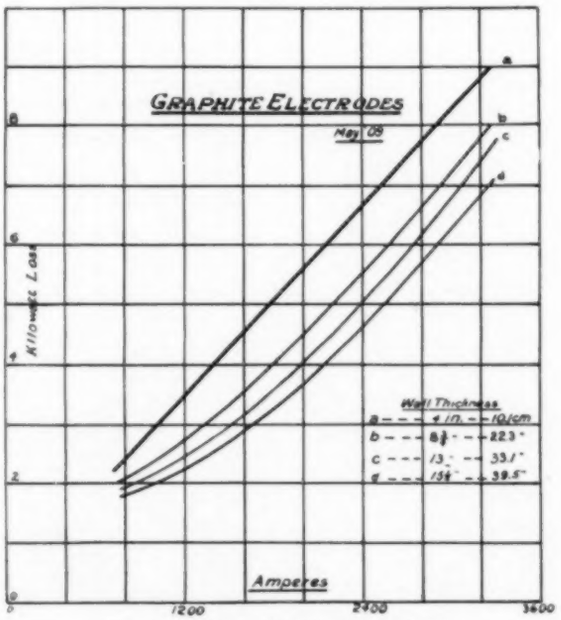


FIG. 3.—CURVES OF ELECTRODE LOSSES.

Time, minutes.	Current amperes.	Wall Thickness 4"	8.75"	13"	15.5"
		kw. loss.			
0	0	2.12	1.81	1.76	1.73
15	850	2.44	2.00	2.00	1.8
30	1125	3.01	2.48	2.35	2.01
45	1250	4.07	2.58	2.48	2.33
60	1700	5.08	3.64	3.18	3.01
75	2025	5.35	4.23	4.00	3.49
90	2375	6.70	5.72	5.17	4.73
105	2900	7.87	6.82	5.57	5.68
120	3000	8.50	7.07	6.95	6.03
135	3200	9.40	7.20	7.15	6.86

Discussion.

The furnace charges were cooled locally at the electrodes during the 1½ hours in which no current flowed. The zero current loss with 4-in. wall thickness was only 2.12 kw in this case, while we found a loss of 3.58 kw when an idle 4-in. x 4-in. graphite electrode passed through a 4-in. wall under the conditions here prevailing at the 90-minute period.

The results cannot, then, be considered as relating to the conditions of equal temperature difference between hot and cold ends of electrode. The ratio $\frac{2.12}{3.58}$ would indicate a temperature difference of about 1600 deg. at the start between hot and cold ends of the electrode passing through the 4-in. wall. The temperature difference would be greater for the longer electrode, since, obviously, in the 1½-hour cooling period, they

conducted away less heat from the furnace interior. Any error introduced is then in favor of the shorter electrode. The temperature difference at the higher currents would be about the same for all electrodes and would approximate 3000 deg. C.

Due to the fact that the water terminals had a considerable water capacity, and pressure in the water mains fluctuated considerably, the results are not so regular as one might wish to have them. This pressure variable would affect all terminals alike, however, since they were all connected to the same main, and we find that each series of readings places the electrodes in the same order.

Calculated to percentage losses, the greater loss being taken as the unit, the results can be far more readily grasped.

Current.	Wall Thickness			
	4"	8.75"	13"	15.5"
amps.	per cent loss.	per cent loss.	per cent loss.	per cent loss.
0	100	85.3	83.0	81.6
850	100	82.0	82.0	73.7
1125	100	82.5	78.2	66.8
1250	100	63.3	60.9	57.3
1700	100	71.7	62.7	58.2
2025	100	79.0	74.7	65.2
2375	100	85.3	77.2	70.8
2900	100	86.5	70.8	72.2
3000	100	83.0	81.8	71.0
3200	100	76.6	76.0	73.0

It is perfectly evident that the gain in increasing length of electrode is greatest at currents below 2000 amp—i.e., current density of 125 amp. Above this value the C^2R loss mounts rapidly with the current, and the gain in efficiency, by increasing wall thickness, is lessened. A reasonable interpretation of the results is given in graphic form in Figs. II and III.

To show how far the results are generally applicable to all electrodes of this type, the following comparisons between losses actually found with losses calculated from the curve sheets here given may be detailed.

Titanium Carbide Furnace.
Electrode 8" x 8" graphite. Wall thickness, 13".

	Current.	Current density. amps. per sq. in.	Loss observed.	Calculated.
1	10,000 amps.	156	22 kw.	21.2
2	14,500 amps.	227	28 kw.	34.4
3	20,000 amps.	312	36 kw.	....

The 20,000-amp loss requires too great an exterpolation of the curves given to make the calculation worth while.

Titanium Carbide Furnace.
Electrode 8" x 8" graphite. Wall thickness 9". Current, 10,000 amperes. C.D. = 156 amps. Calculated loss, 23.6 kw. Observed loss, 27.5 kw.

Graphite Furnace. (Separate experiment with another furnace).
Electrode 4" x 4" graphite. Wall thickness, 4¼". Current, 2520 amperes. C.D. = 157 amps. Loss, 6.98 kw. Calculated loss, 6.9 kw.

The agreement between observed results on 8-in. x 8-in. electrodes and those obtained by using the curves taken from the 4-in. x 4-in. electrodes is not perfect by any means, but the results so taken are at least fair approximations of the losses actually found and come much closer to the actually observed losses than values calculated from the resistance and heat conductivity figures at present available.

It is apparent from the data given that the efficiency of a graphite electrode, regardless of its length, within reasonable limits, of course, increases rapidly with increasing current density. Its efficiency increases also, as we have seen, with increasing length. It must be borne in mind, however, that the higher the current density the hotter becomes the electrode embedded in the furnace wall, and a limit is soon reached at which the refractories melt down.

As an example of this, we have found that at 10,000 amp an 8-in. x 8-in. graphite electrode and its 13-in. wall will last for 50 or more runs of 10 hours each—the wall failing, not the electrode. At 15,000 amp, with the same apparatus, the wall usually lasts four or five runs and occasionally twice that number. At 20,000 amp the furnace has repeatedly blown out around the electrode after running a few hours. The carborundum packing used was completely decomposed into spongy graphite and volatile silicon; the wall melted down about the electrode and was reduced at the expense of the electrode. Electrode and wall had, therefore, to be replaced, an expense per run, then, of approximately $60, which, of course, no power efficiency gain would begin to cover.

Increasing length of electrode at lower current densities will bring about the same result.

With carbon electrodes it would appear that increasing length of electrode would bring about a decrease of electrode efficiency, for the reason that the C^2R loss is much greater than the heat conduction loss, even in very short electrodes. This will, however, be worked out at some future time.

Research Laboratory,
General Electric Company,
Schenectady, N. Y.

Brooklyn Meeting of the American Institute of Chemical Engineers.

In our last issue we noticed briefly the semi-annual meeting of the American Institute of Chemical Engineers, held in Brooklyn, on June 24, 25 and 26. It was again a full success and especially the social functions, the dinner at Brighton Beach, and the excursions on Friday and Saturday, were greatly enjoyed, everybody being pleased with this feature of the meeting and the excellent arrangements. The program of the excursions was already given in our last issue.

At the subscription dinner at Brighton Beach some enthsiastic speeches were made by members and non-members. Dr. McKenna, Dr. Wm. T. Mason, and Mr. Stephen P. Sharples gave toasts for the Institute, while Prof. J. W. Richards spoke for the sister societies. The keynote of all the addresses was the function of the Institute. Professor Richards emphasized the fact that the Institute comprised a group of men engaged in technical work and that the technical application of scientific theories would be the field for its activity. He said that he had no doubts whatever as to the future of this sturdy infant of the chemical profession, that it was a natural growth and as such could not be suppressed.

We herewith give abstracts of the papers presented in the two sessions on Thursday morning and afternoon.

* * *

Prof. WILLIAM D. ENNIS, Polytechnic Institute, Brooklyn, spoke on the Efficiency Limits in the Power Gas Producer.

The difficulty of separately and accurately determining the efficiency of a gas producer suggests a computation of its efficiency limits. When pure carbon is converted into carbon monoxide, 30.69 per cent of its potential heating value is "transformed into temperature" and becomes unavailable for use in the gas engine.

By using a certain proportion of steam mixed with the air supplied for gasification the "temperature heat" may be partially employed in decomposing the steam. The hydrogen then carries this temperature heat to the engine as available heat of combustion. With sufficient steam supplied the temperature elevation might be eliminated, and the efficiency would be 100 per cent. Steam will not decompose readily at temperatures below 1740° Fahr., however, and the proportion of steam must be limited to that at which this temperature is attained. The efficiency is then, theoretically, 83 per cent.

A corresponding result follows the introduction to the producer ash pit of a portion of the waste gases discharged in the engine exhaust. The carbon dioxide then decomposes, and the heat absorbed is carried back to the engine. At the limiting temperature mentioned, the efficiency is 78½ per cent.

Modifying these results to include practical losses by radiation, fuel in ash, etc., variable specific heats of the gases, the presence of hydrocarbons in the fuel, the rise of surplus oxygen in the engine and in the producer, the initial temperature of the steam or waste gas and the formation of carbon dioxide, the maximum possible efficiency, with steam, appears to be less than 80 per cent, and with waste gas slightly less still.

Actual analyses of gases produced by the two methods check the computation to some extent. The conclusion is drawn that the temperature of the gas is the best crude indication of efficiency of operation.

The paper was discussed at considerable length.

A paper on the **Utilization of Low-Grade Fuels** was then presented by Dr. O. K. Zwingenberger, consulting engineer, of New York City. The paper is printed in full elsewhere in this issue (page 347).

During the recess at noon, Mr. Jerome Alexander made an interesting exhibition of the **Ultra-Microscope.**

In the afternoon sessions Dr. Samuel P. Sadtler, consulting chemist, of Philadelphia, and president of the Institute, presented a paper on **"Creosote Oil from Water Gas Tar."**

Dr. Sadtler gave a summary of the specifications for creosote oil used in the United States and Europe and showed that the present weight of opinion is in favor of the use of heavy oils rather than the phenols and naphthalene which have been specified in the past.

A resumé of the literature on the subject was given, and it was shown that a study of the creosotes recovered from timber which has been in service for periods ranging from nine to 47 years shows the presence of a very large percentage of oils boiling above 205° C.

The paper gave the results of the examination of a creosote fraction obtained from water-gas tar. This fraction is very similar to that obtained from the creosoting fraction of coal tar. While the author was not willing to express a final opinion on these results, but held them subject to confirmation by additional distillations, he did state that this grade of water-gas tar creosote may be quite specifically adapted to wood preservation.

A paper by Dr. Charles F. McKenna, consulting chemist, of New York City, on the **Centering of Great Industries in the New York Metropolitan District,** is published in full elsewhere in this issue (page 341).

Dr. J. C. Olsen and John S. Weiffenback, Polytechnic Institute, Brooklyn, described **Some Experiments on the Case Hardening of Steel with Gases.**

The authors gave the results of experiments on case-hardening of soft Norwegian iron with various gases, carried on at the Polytechnic Institute. It was shown that in most cases nitrogen in the form of ammonia facilitates the action of carbonizing gases. Nitrogen in the free state has no influence on the carbonizing action. It was shown that the ammonia does not react with the carbon gases to form cyanogen.

Carbon monoxide seems to act almost as well without as with ammonia. The depth to which the carbon penetrates and the percentage of carbon in the case were determined by analysis. The chemical reactions taking place during the carbonization were determined as follows:

With carbon monoxide, $2\,CO = C + CO_2$.

With methane, $CH_4 = C + 2\,H_2$.

With acetylene two reactions seem to take place, as follows:

$$2\,C_2H_2 = CH_4 + 3\,C,$$

and

$$C_2H_2 = C_2 + H_2.$$

The carbonizing ability of the gases studied ranges according to the following order: Carbon monoxide, acetylene, illuminating gas, methane. Carbon monoxide is by far the best gas for this purpose.

Mr. Richard K. Meade, consulting chemical engineer, of Nazareth, Pa., described **An Automatic Acid Egg,** in which the valve is opened and closed automatically by means of an electrical device.

Mr. J. G. Dean, of Exshaw, Alberta, Canada, described the **Method of Clay Control as Practiced by the Western Canada Cement & Coal Company, Ltd.**

The author described the method adopted to overcome the difficulties presented by the use of clay low in silica and high in iron oxide and alumina, rendered it necessary to add limestone to secure the proper silica-alumina ratio. As this proved unsatisfactory, a shale having a high silica-alumina ratio and a slate having a low ratio were mixed in the proper proportions to secure the ratio necessary for cement.

The arrangement of the bins and conveyors was described, and the formula used for calculating the proportions by which the materials are mixed; also formula for calculating the percentage of limestone to be added. On proper grinding a perfectly uniform quality of cement was produced which was in perfect chemical balance, having no erratic or freakish features.

New Norwegian Carbide and Cyanamide Works.

To complete our articles on the new calcium carbide and calcium cyanamide works at Odda, Norway, in our May issue, pages 212 to 216, and in our July issue, pages 309 to 313, we will describe the cyanamide furnace plant, the description being taken from London *Engineering,* June 11.

In the furnace house there are 196 electric furnaces capable of producing about 1 ton of nitrolime per week, each furnace taking three charges per week. These furnaces are arranged in rows of seven, as is shown in the perspective view, and the retorts they contain are transported between their position on the furnace benches and the charging-hopper by the overhead electric traveler.

On being returned to their furnace, the necessary connections are made for the supply of nitrogen and for the electric current, which is passed through central carbon resistances in order that a temperature of from 800 deg. C to 1000 deg. C. may be secured to induce nitrification. The nitrogen to be combined with the carbide (delivered at the rate of about 13,000 cu. ft. per hour) is supplied to these retorts through mains from the Linde house already described, a large meter being interposed in order to control the pressure and supply. There are also at each furnace suitable regulating valves and small controlmeters.

The absorption of the nitrogen occupies some 30 to 40 hours, and care has to be exercised to ensure a uniform temperature so as to finally fix the required percentage of nitrogen in the nitrolime. The calcium carbide powder has in the process been converted into an exceptionally hard substance, not unlike coke in appearance, and has at the same time contracted considerably in volume, so that its removal from the retort is not difficult.

It has, however, first to be cooled, and the retort, for this purpose, is allowed to stand from 8 to 12 hours on a grid, under which a current of cold air is passed. The contents are afterwards fed into the hopper in the cyanamide-grinding house.

Exception has been taken to the process because of the small contents of the retorts, and the assumption that this involved a large amount of manual labor. Experience, however, made the use of a small furnace practically imperative, as thereby alone thorough reliability in the finished product can be attained.

It became a comparatively simple matter to devise means to economize the amount of labor involved. The motive power is cheap, and ingenuity has enabled the general arrangements of the plant to be such as to involve a minimum of handling. Forty-five men suffice for the furnace-house, and these men work in three shifts, so that the labor cost for over 200 tons of nitrolime is little more than $3 to $3.25 a ton.

The subsequent grinding of the nitrolime is carried out in a special grinding house, the material being delivered there by conveyors, which feed a gatemill, whence elevators and worms take it to hoppers discharging into ball mills. It is led by worm conveyors into elevators, which ultimately deliver it into the silos.

The Odda carbide and cyanamide works are supplied with three-phase currents from the Gysse station at 11,000 volts, the total power being 20,000 electrical horse-power. The larger part of this energy is used for the electric control furnaces.

There is a primary switchboard having 14 switches, 12 of which are respectively for the 12 furnaces. Another is for controlling the current to the cyanamide works, and one more for passing the current to the low-tension station, to be referred to later. A single-phase static transformer is located directly

under each carbide furnace, and the voltage is reduced from 11,100 to 50, giving a current of 28,000 amp. Each furnace transformer is placed between two phases, and these are interchangeable, so that there is no possibility of a complete stoppage owing to failure of the electric current. The transformers are cooled by induction fans, which draw their current through the

CYANAMIDE FURNACE BUILDING.

tunnel, so that the temperature of the air is considerably below that of the atmosphere.

The low-tension transformer is also of the static air-cooled type, and reduces the voltage to 400. The current is subsequently controlled at a switchboard. A large part of the three-phase current of 400 volts is used for driving the workshops and large motors. The remainder is converted into direct current at 220-volts pressure, which again has a separate switchboard and the current is used for lighting and for driving the small power motors, the electric railway locomotive, and the small wagons on the telpher railway.

Dwelling houses have been erected for the workmen, about 200 yd. from the factory. Twenty have already been completed, each for four families.

The earnings of the workmen vary from 80 kr. ($21.44) up to 150 kr. ($40.20) per month, with an average of about 100 kr. ($26.80 per month). The companies try for the most part to employ married men, as they are quieter and more conscientious in their work. The works are associated with the State insurance establishment for workmen, so that they are insured in case of accidents, and a sick club is likely to be established.

"The companies have succeeded in their endeavor not to spoil the amenities of this beauty spot in the Soldal Fjord. The works have greatly added to the prosperity and well-being of the population, and the evidences of commercialism are neither obtrusive nor unpleasant, certainly not more unpleasant than the suggestion of poverty and hardship which exist in so many of the Norwegian hamlets, and which may, as at Odda, give place in the future to active and prosperous industry."

Notes on Electrochemistry and Metallurgy in Great Britain.

(From our London Correspondent.)

Iron and Steel Institute.

A brief account of the spring meeting, held May 13 and 14, in London, has already been given in our June issue, page 286. In the following we give an account of the discussions:

Corrosion of Steel.

The three papers on "The Electrolytic Theory of the Corrosion of Iron and Its Applications," by Dr. W. H. Walker, of Boston, Mass.; "The Preservation of Iron and Steel," by Dr. A. S. Cushman, of Washington, D. C., and "The Value of Physical Tests in the Selection and Testing of Protective Coatings for Iron and Steel," by Mr. J. Cruickshank Smith, were read and discussed collectively. Concerning the electrolytic theory of corrosion of iron and steel and the part which Dr. Cushman and Dr. Walker have taken in the development of this theory a vast amount of information has been published in our last two volumes.

Mr. J. E. Stead opened the discussion, and conducted some of the experiments demonstrating the passive condition of steel produced by potassic bichromate. He considers the author's methods to be a beautiful illustration of the electrolytic theory and quite convincing. Dr. Cushman had omitted mentioning the remarkable effects of a slight amount of impurities on steel, but bearing these in mind, it was easy to understand how corrosion was set up. With regard to Dr. Walker's references to segregation effects, the segregation of the carbon in small masses of pearlite, which were quite different from ferrite, set up a condition of electrolytic tension in the steel with consequent formation of electrolytic couples on the surface. Although segregation always occurred below the suface, pitting resulted on the surface; and this indicated that pitting was not dependent on segregation, but resulted from the way in which the anodes and cathodes formed couples. He had tested English tin plates by the electrolytic methods, and the results proved their superiority over American plates. He had noticed that when steel plates for ships were marked whilst hot the paint had a much enhanced effect in preventing corrosion; and he held the view that protective paints should be applied to the plates while in a heated condition, so that moisture was entirely eliminated. Every practical engineer knew that plates painted hot lasted longer than those which had been painted cold.

Mr. E. A. Saniter said he should like to see a complete analysis of the especial kind of iron dealt with in Cushman's paper and stated to contain 99.5 per cent of iron. With regard to Dr. Cushman's reference to corrosion tests with acids, practical experience demonstrated that steel which was most attacked by sulphuric acid in laboratory experiments was least affected in actual use in the open.

Mr. B. Philips Smith eulogized Walker's attitude in setting forth the theory and details of his experiments without deducing therefrom any specific conclusion inimical to a particular commercial process, as Cushman had done, who from results of laboratory experiments formulated an attack on graphite pigment as a substance promoting corrosion; but tests of pigments with an aqueous vehicle afforded no information as to the action of such pigments mixed with linseed oil, as they were in actual use. To arrive at true conclusions experiments should be conducted more carefully and with regard to normal conditions.

He remembered an expression of opinion that because ferromanganese—which was a carbide—decomposed water, less than 1 per cent of manganese in steel would act similarly and increase liability to corrosion. Yet Hadfield's manganese steel

containing 13 per cent of manganese was not so easily corroded as iron. He believed that a Mr. Cushman was responsible for the opinion in question, and he wished to know if that Mr. Cushman was the author of the paper under discussion. Mr. M. P. Wood had pointed out that graphite pigments were electro-negative and less susceptible to catalytic or electrolytic action than any other class of pigments with the exception of lampblack. The careless use of iron oxide and of compounded pigments was the cause of much corrosion in important iron structures. Mr. Cushman appeared to have overlooked the importance of the nature of the vehicle, and the value of a correct description of graphite paint was not diminished by Cushman's finding that some kind of graphite, not specified, did not, when mixed with water, give protection to a knife blade.

Professor Turner said he was not prepared to go all the way with Mr. Cushman, but found points on which he could agree. Attention has been drawn by numerous observers—including Dr. Tilden—to the effect of small quantities of foreign bodies on the surfaces of metal. Mr. Stead had called attention to the importance of using well-boiled tar or oil, which was much more effective than if applied cool.

Mr. G. H. Strick, as a maker of tin-plate, remarked that imperfections were mainly due to faults in the metal previous to tinning. Recently more attention to the securing of a good, clean surface had resulted in an improved production.

Mr. F. A. Willcox asked if experiments had been made with a paint containing a celluloid base. He had used a solution of celluloid in amyl acetate to prevent pitting in propeller blades, and the samples had remained in good preservation for 10 years, except at the tips.

Mr. Cushman then replied: He had advised American manufacturers to pay more attention to quality than to quantity, and some had followed his advice and consulted him, with the result that several mills had adopted new methods. He would seek to eliminate the impurities which were now allowed in their plates, although he was aware that in doing so other troubles were introduced. They must think of something more than turning out a quantity of metal and selling it. The 99.5 per cent iron referred to contained only traces of arsenic, copper, and other impurities which had been mentioned. He agreed that the acid test was not fair. Its action was quite different from that of the atmosphere, which was quiescent and gradual. Aluminium, if properly used at a correct temperature, left no oxide in the metal. The prohibition of the use of artificial coloring matter to counteract the sickly color of the fruit syrups caused by the tin, in canned goods, led to the reduction of the tin coating on the iron to an extent which resulted in the cans being perforated by the acid fruit juices which squirted through the pinholes they had caused. The application of Dr. Walker's ferroxyl test to tin plates gave possibilities of great advances. It was essential in this test to ensure absence of dust. With regard to celluloid paints, he had made many experiments with amyl acetate and with chromatised paints, but his most successful lacquer he made by adding chromic acid, in small quantities at a time, to an alcohol solution of shellac, and this had given excellent results as protective for steel surfaces.

The president, Sir Hugh Bell, moved a vote of thanks to the authors and said he appreciated Mr. Cushman's sub-acid remarks concerning American productions all the more because they were directed on Americans by an American. He also wished to thank Mr. Cushman for his side remarks on the subject of waste—a question of very vast importance to those living to-day—for, if waste could be reduced, 10 per cent of all those conditions which statesmen and others were seeking to remedy could be removed. The question of the preservation of iron and steel was of the utmost importance; for the extent to which buildings depended on these materials for their mainstay was great and continually growing, but immense structures were being erected under conditions of ignorance as to what changes the future might bring forth. Mr. Walker had emphasized the necessity for adequate protection of the iron reinforcement of concrete, and the desirability of the concrete being dense and impervious to water. He asked those present to consider whether due precautions were being observed in the use of reinforced concrete in modern iron buildings, and whether there were not a possibility of some serious disaster occurring soon in connection with buildings of that class.

A paper was then presented by Prof. E. Heyn and O. Bauer on the influence of the treatment on the solubility of steel in sulphuric acid, and deductions therefrom as to the nature of the treatment to which it had been previously subjected.

The discussion of this paper was opened by Mr. Stromeyer, who said that he was greatly interested in the fact demonstrated by one of the diagrams that heat treatment was effective at so low a temperature as 100 deg. C., because he had no doubt about such changes occurring at even still lower temperatures. Much of the ground he had gone over on the ageing of steel was covered by the paper. He maintained that a complete reproduction of the ageing effect could be obtained by boiling steel for 15 minutes, but the paper made it appear that much more prolonged boiling would be requisite.

Mr. J. E. Stead remarked on the effect of crushing steel in producing physical change leading to liability to oxidation. The work the authors had done confirmed previous researches on the solubility of steel, and they appeared to prove that the critical point in annealing was 400 deg. C.

Dr. W. Rosenhain considered that the description of the results obtained by heating steel above and below 400 deg. C were most instructive and valuable. The authors believed they had discovered a new constituent of steel, which they had named osmondite, but he thought that the extension of the list of names was not desirable, and would not be of assistance in explaining observed phenomena. Below 400 deg. C. the metal might be considered to consist of martensite and troostite, and at that temperature there was disappearance of martensite and initial pearlitic metamorphosis.

Mr. Saniter thought that the reliability of the authors' analytical methods was established by the results. It appeared that residual carbon was at a maximum at 400 deg. C., when formation of sorbite began, while at 600 deg. C the hardening effect of quenching was eliminated. His own experience agreed with this.

Decarburization of Iron.

Mr. W. H. Hatfield presented a paper on "the chemical physics involved in the decarburization of iron-carbon alloys." The question at issue is the theory of Wüst that in the decarburization of white iron it is essential that the carbon be out of solution (or combination) as temper carbon before the action of the oxidizing influences which are to eliminate it can take place. Mr. Hatfield strongly denies this theory. In his opinion it is not necessary that the carbon be precipitated as temper carbon before its removal. Should temper carbon be produced, it is most likely that only that temper carbon which has recombined with the iron by diffusion, can be removed.

Mr. J. E. Stead led the discussion by briefly remarking that his personal experiences induced him to consider that Mr. Hatfield's conclusions were established.

Prof. G. Turner agreed generally with the author; but there was one point—a small matter—on which he differed, viz., that the percentages of sulphur were the same in converted and in unconverted bars, for he found sulphur was diminished. He had never found precipitated carbon present during the process of elimination. Some years since, he had pointed out, in a paper, that the separation of graphite from cast iron was accompanied by evolution of heat; but more heat was evolved in burning the carbon out of the iron than in the combustion of the carbon alone.

Mr. E. Adamson said Mr. Hatfield's results were in accordance with some of his own.

Prof. A. McWilliam remarked that it was usual to consider

that no good could come out of Sheffield, while all that came from Germany was approved. But he thought Mr. Hatfield had demonstrated the correctness of the older views on the subject, and that Dr. Wüst had got shunted on a side track in the matter.

Mr. Hatfield, in his reply, said his work had been done to ascertain the correctness of the views held on the subject, and he was much gratified to know that Mr. Stead, Professor Turner, Professor McWilliam and others agreed with him. As to the point raised by Professor Turner on the sulphur content, the figures given were actual determinations; but in view of existing evidence that the annealing of malleable iron did diminish the sulphur, he intended to give further attention to the question.

Electric Steel Furnaces.

The second day of the meeting brought Mr. W. Rodenhauser's paper on "the electric furnace and electric process of steel making," and an interesting discussion followed.

The discussion was opened by Mr. Arthur Windsor Richards, who said that where conditions were favorable to the supply of cheap power, no doubt the electric furnace had come to stay, at all events for high-class steels; but the electric production of steel must be effected more cheaply before it could compete with the Bessemer and open-hearth processes. It was true that analyses showed that electrically produced steel was very good, but its cost was very great, and that led to the consideration of a point in the manufacture of the rail steel which the author had produced in the Roechling-Rodenhauser furnace. The blown metal contained 0.08 per cent of phosphorus and 0.1 per cent of sulphur, and in the furnace these amounts were reduced to 0.023 and 0.044 per cent, respectively. Physical tests had shown that that material was very satisfactory, but steel fully equal to it was being made by the basic open-hearth process at a much lower cost. He asked if the author had intentionally stopped the process when the percentages of phosphorus and sulphur were reduced to the figures just given. If so, he quite agreed that it was neither necessary nor beneficial to reduce those substances to a lower quantity in rail steel with high carbon. If the arrest at the point was not intentional, was that so because he failed in the reduction in consequence of the heat of the induction furnace not having been sufficient? It had been said that the high qualities of electric furnace steel were not entirely due to the small percentage of impurities in it. He thought they were accounted for by the nearly total absence of gases—mostly nitrogen and oxygen—combined or mixed with the metal.

Mr. J. Gledhill concurred in the view that the advent of the electric furnace opened up for makers of steel a new vista. He thought, however, that questions of cost were the main factor, and that electric smelting was not likely to compete satisfactorily with the other processes. His own firm had been recovering the by-products—chiefly ammonium sulphate—and had consequently considerably reduced the cost of smelting. Practically, a ton of coal yielded 80 lb. to 90 lb. of ammonium sulphate, worth £11 to £12 per ton. The coal cost 9s. to 10s. per ton, and the economy was manifest. He admitted that the electric furnace produced an excellent material, but he wished to point out that the ordinary processes produced an equally good material. He believed that there was a great future for the electric furnace, but much remained to be done before it could compete on the large scale with existing processes. Information as to first cost and depreciation was desirable for comparison with those of ordinary plants.

Mr. Otto Frick did not agree with some of the author's points. The main reason why the Stassano furnace was unsuitable for large charges was the position of the electrodes, and the longer electrodes in the larger furnaces were more liable to break. The author had said that in the Girod furnace the consumption of energy was more constant and the generators consequently worked under better conditions. That was hardly correct; the variation in the energy required was due to short-circuits between the electrodes and the steel. In the case of a 300-kw furnace, quoted by the author, the heat produced by the passage of current through the steel was only the equivalent of about 10 watts, or 0.033 per cent of the total energy. The contention of the author that in arc furnaces the charge was almost entirely heated by the arc was certainly correct, but in these furnaces the heat developed in the arc first heated the air or gases in the furnace from which it was conveyed to the metal through the slag.

A furnace of the Frick type was in regular work at the Krupp works, Essen, since August last, with a capacity of 10 tons, consuming 1000 hp, and such satisfactory results had been produced that Krupp's had secured exclusive rights in the German patents. The author said that the shape of the hearth in the Frick furnace prevented the removal of slag, and that these furnaces were only adapted for pure materials. That might be true of the Kjellin furnace, but not of the Frick furnace, which had the cover of the crucible in one piece and capable of rotation in such manner that every part could be inspected through one opening. It was easy to bring the slag to the spout with the skimmer and draw it out, but he did not recommend this way of slagging, but preferred to entirely empty the furnace into a ladle and to return it from the bottom of the ladle, leaving the slag in that. By this method a much more complete separation of the slag from the metal was effected. The author claimed, too, that the first cost of the dynamo was lower than in the Frick system, but the difference was unimportant; and the lower radiation losses in the Frick system would be equivalent to a saving of 15 per cent per annum in working expenses where current cost ½d. per unit. He believed that the best economical results would be achieved by the electric furnace as supplementing the Bessemer and Siemens-Martin furnaces. The efficiency was much the same as that of a Siemens furnace.

Mr. Hiorth said that the annular parts of the Roechling-Rodenhauser furnace bath represented a double furnace similar to the Kjellin, i.e., the bath was heated by pure induction currents at a low pressure of 8 volts to 12 volts, while the rectangular bath was heated by currents of higher voltage between the terminal plates. The currents of higher voltage had to traverse copper, iron and a layer of refractory material, and was the loss of energy less than with carbon electrodes in an arc furnace? In consideration of the very high efficiency of the Roechling-Rodenhauser furnace, given as 97 per cent, it seemed that the consumption of energy in the annular parts of the bath was very small. That part of the bath incurred great loss of energy owing to the extent of its radiating surface, and there was a danger of the steel breaking through the wall.

Why retain the induction principle at all when it reduced efficiency electrically, thermally and practically? He agreed with the author that the Kjellin furnace was not suited for large capacities, and even with a five-cycle, alternating current a 10-ton furnace would never be efficient. The ideal steel furnace for large charges was apparently the "pure induction" plant constructed closely in conformity with the ordinary transformer, namely, with the primary windings as close as possible to the bath. From his own experience in working a 500-kw furnace he considered it possible, with a three-phase current and a good power factor, to smelt 40 to 50 tons at a time. The "pure induction" furnace was, he thought, the best solution of the problem.

Professor McWilliams said that he and the electrical expert of the metallurgical department of the Sheffield University had examined the working of the Kjellin furnace. A furnace had been purchased, and experiments were going to be carried out. The cost of the electric furnace was not the most important matter; the quality of the product was of consequence. That question had arisen in connection with one important company which was giving a higher price for steel rails finished in the electric furnace after having been made by the open-hearth furnace.

SYNOPSIS OF PERIODICAL LITERATURE

Coal Dust and Mine Explosions.—Before the Congress of Applied Chemistry Prof. Galloway read a paper on "Coal Dust," reviewing the subject, and his efforts to obtain recognition from the official inspectors of mines in England for the dangers due to this cause, with some details of the methods now used for minimizing the danger. The use of dust-tight wagons for hauling purposes, and of damping the floor of the mines at regular intervals, were two of the remedial proposals suggested by the author, and he also suggested the use of hydroscopic salts or "stine" dust for this latter purpose. This proposal had recently formed the subject of experimental trials at Normanton, in Yorkshire, and at Lievin, in the north of France. It had been suggested, further, as a means for preventing the spread of explosions from one part of the mine to another, that a certain length of each roadway should be lined with brick or concrete and kept always wet. The Royal Commission on Mines, which was sitting, was considering these and other proposals for minimizing the special dangers due to the presence of coal dust in mines. A second paper on this subject was prepared by Berg-Assessor Forstmann and related to the study of the same question in the Westphalian coal mining area in Germany. Since Jan. 1, 1899, certain mines in this district have adopted sprinkling methods for keeping the coal dust moist. In some cases a special network of water pipes had been installed along all the galleries and working places of the mine, and special men had been appointed to look after this work. Although explosions had occurred in these mines since the date named, the author considered the sprinkling method was the best of those proposed for minimizing the dangers due to coal dust.—(*The Engineer*, London, June 11.)

Alloys by Electrodeposition.—A paper read before the Faraday Society on June 29 by Mr. S. Field deals with "the conditions which determine the composition of electrodeposited alloys." In the present paper the author deals with copper-zinc alloys. As the result of a large number of experiments on the electrolytic deposition of brass, he has, by the analysis of the deposits, shown the regular manner in which the composition changes with such varying conditions as (1) proportion of copper and zinc compounds in the solution; (2) strength of the solution; (3) temperature; (4) current density, and (5) the presence of free cyanide. It is thus shown that the proportion of zinc is increased (*a*) at lower temperatures; (*b*) with more dilute solutions; (*c*) with increased current density, and (*d*) by the absence of free cyanide. With a large proportion of zinc compound copper is still freely deposited. The author incidentally draws attention to a number of important conditions which primarily affect the composition of the solution and ultimately the character and composition of the deposit. The work is being continued on other binary alloys. (From advance sheets.)

Electroanalysis.—At a meeting of the Faraday Society, held on June 29, Dr. Henry J. S. Sand read a paper on "Apparatus for the Rapid Electroanalytical Separation of Metals." The paper contains a description of some developments made in the apparatus, first described by the author about two years ago, for the rapid electroanalytical depositio nand separation of metals [*Chem. Soc. Trans.* 91, 373 (1907); also *Trans.* 93, 1572 (1908)]. This apparatus combined in a practical manner the use of an auxiliary electrode and very rapid stirring of the electrolyte, and made it possible to deposit and separate from each other for purposes of chemical analysis the metals silver, mercury, copper, bismuth, lead, cadmium, zinc, antimony, and tin. The times required for these depositions varied in the majority of cases between 5 and 15 minutes. Apart from the very high stirring efficiency of the electrodes the apparatus is believed to be superior to others of similar type in the very great simplicity of the method of making and undoing the electrical connections on a single stand, in the fact that the electrodes may be used with ordinary beakers, and in the simple manner in which the electrodes may be washed and dried. No alterations in principle have therefore been made to the apparatus, but the following additions and simplifications are described.

As hitherto, a mercury contact has been employed in the electrolytic stand to make the connection between the stationary and the moving parts; a special screw cap has, however, now been provided, which may be screwed down when the apparatus is not in use, making it possible to transport it without taking out the mercury. A clutch arrangement has been added which enables the operator to start or stop the rotation of the anode without stopping the motor. Such an arrangement will be found of advantage if it is desired to actuate several sets of apparatus from one shaft driven by a single motor; or if the current is obtained from a small motor-generator which is also employed for rotating the electrode, the clutch making it possible to stop or start the stirrer without stopping the current; or lastly, if a hot air or water motor is employed which cannot be stopped instantly during the washing of the electrodes. A very considerable simplification has been obtained by fitting all the apparatus required for the measurement of the potential of the electrode in a single box. The arrangement has been designed so that by depressing a key it will also allow the potential difference between the anode and the cathode to be read directly. It was thought very desirable to retain the capillary electrometer as a zero instrument, but it became necessary to design a new portable form suitable for the purpose in view. It may be described as a closed evacuated form developed from the Ostwald horizontal capillary electrometer. It is provided with an enclosed scale, and if observed by a lens of small magnification it will readily indicate one millivolt. (From advance sheets.)

Platinum Thermometer.—C. W. Waidner and G. K. Burgess, of the Bureau of Standards, have carried out an experimental investigation on the platinum thermometer at high temperatures and presented the results before the Physical Society. Our abstract is taken from the *Physical Review* of June. The authors investigated the applicability of the Callendar formula for the calibration of platinum thermometers, in the range 0 deg. to 1100 deg. C., for platinum of different degrees of purity. Platinum temperatures are numerically defined in terms of the resistance of platinum as follows:

$$pt = 100\,(R - R_0)\,/\,(R_{100} - R_0),$$

and the difference between platinum and gas scale temperatures is given by the formula:

$$t - pt = \delta\,(t/100 - 1)\,t/100$$

The fundamental interval *F.I.* is evidently $R_{100} - R_0$, and the fundamental coefficient, $c = (R_{100} - R_0)/100R_0$. The constants δ and c are characteristic of the material of the thermometer. Calibrations are made at 0 deg., 100 deg., and 444.70 deg. C. (the boiling point of sulphur) giving the values of R_0, R_{100}, and R_s, respectively, from which data any other temperature may be computed from the observed resistance R.

Nine platinum thermometers were used of wire, varying in diameter from 0.1 to 0.6 mm and having a range of R_0 from 0.11 to 21.3, of c from 0.0039 to 0.0017 and of δ from 1.50 to 1.80. The thermometers were of the compensated and of the potential lead types; some of the measurements were taken by a potentiometer method, some by means of a special Wheatstone bridge, and some of the thermometers were adapted to measurements by three methods, the potentiometer, the Wheatstone bridge, and the Kelvin double bridge. The resistance measurements were made to 1 or 2 parts in 100,000.

The metals were used in crucibles of pure graphite with powdered graphite covering them and in amounts of 1.5 to 2 kg, ensuring ample depth of immersion of the coil and of the thermometer. The melting and freezing point determinations were carried out in vertical electric resistance furnaces wound with two platinum ribbon heating coils on concentric porcelain tubes, the windings being so spaced as to give quite uniform temperature distribution throughout a considerable length of

the furnaces. The temperature could be maintained constant to within a few hundredths of a degree for many minutes at a time during the freezing or melting of the metal. By stirring with the thermometer, under-cooling could be practically avoided. The results of the freezing point determinations are shown in the table.

It will be seen that for pure platinum, for which $\delta = 1.50$, the Callendar equation is in agreement with the generally accepted gas scale to within the limits of reproducibility of the latter, or 1 deg. C., but for impure platinum this equation no longer holds good.

The effect of high temperatures on the constants of platinum thermometers is in general to reduce the value of R_0 and increase *F.I.* The effect on δ is very small. Measurements made with pure platinum thermometers of heavy wire (diameter = 0.6 mm) without the usual mica-supporting frame, show unusually small changes in R_0, even after several heatings for some hours at 1250 deg. changes equivalent to only a few tenths degree C.

Thermometers of pure palladium were also tried, for which $\delta = 2.89$ and $c = 0.00336$. They do not satisfy the Callendar equation; for example, it leads to a value of 1152 deg. C. for the *F.P.* of copper. The effects due to heating are similar to those found for platinum.

Four *Pt*, *Pt — Rh* thermocouples, of slightly differing composition calibrated in terms of the equation $T = a + bE - cE^2$ at three of the freezing points in the table (Zn, Sb, Cu or Zn, Ag — Cu, Cu), as given by the platinum resistance thermometer, agree with each other to within 0.3 deg. at intermediate temperatures, and to within 1 deg. with the scale as defined by the thermometer of pure platinum.

Temperature.	Platinum, mean.	Platinum, actual.	$MgCaSi_2O_6$ mean.	$MgCaSi_2O_6$ actual.	$CaSiO_3$ mean.	$CaSiO_3$ actual.
100°	.....	.....	0.1920	0.2050	0.1833	0.1916
500	0.03351	0.03560	.2310	.2668	.2170	.2510
700	.03425	.03685	.2420	....	.2288	....
900	.03515	.03799	.2490	.2810	.2355	.2604
1100	.03575	.03901	.2563	....	.2400	....
1300	.03644	.04003	.2600	.2800	.2420	.2510
1500	.03679	.04073	....	....	....	....

temperature. The accidental variations of the results were thus brought in nearly all cases below 0.5 per cent, usually below 0.2 per cent. The systematic errors are probably not much larger, but are to be further investigated. Meanwhile, the results seem trustworthy, to 1 per cent, except above 1400 deg., and as little is known of specific heats in the region covered, a preliminary publication of some illustrative substances is now given. The temperature scale was determined from experiments still in progress at the Geophysical Laboratory, and does not contribute appreciably to the systematic error, except, again, possibly at the highest temperatures. The following values for platinum and two pure crystalline silicates are of the mean specific heat from 0 up, which was directly determined, and of the actual specific heat at each temperature, derived from this. The results for $CaSiO_3$ are within 1 per cent of those obtained a year ago. These data agree within 0.5 per cent, in most cases much closer, with the following formulas for the mean specific heat:

Pt. $0.03198 + 3.4 \times 10^{-5} T$ or $0.03198 + 3.967 \times {}^{-6} T - 4.67 \times 10^{-10} T^2$

$CaMgSi_2O_6$ $0.1779 + 1.516 \times 10^{-4} T - 1.047 \times 10^{-7} T^2 + 2.81 \times 10^{-11} T^3$

$CaSiO_3$ $0.1722 + 1.18 \times 10^{-4} T - 6.16 \times 10^{-8} T^2 + 9.4 \times 10^{-12} T^3$

The linear equation for platinum is the more convenient, the

SCALE OF PLATINUM THERMOMETER—CALLENDAR FORMULA—CALIBRATION DATA
(S = 444° 70C.)

Metal	$\delta = 1.505$, $c = 0.00383$ to 390					$\delta = 1.570$, $c = 0.00206$ to 210					$\delta = 1.803$, $c = 0.00173$			
	Temp. Calc.	Range Deg. C	Number of Obs.	Number of Samples	Number of Therms.	Temp. Calc.	Range Deg. C.	Number of Obs.	Number of Samples	Number of Therms.	Temp. Calc.	Range Deg. C	No. of Obs.	Gas Scale Holborn and Day
Sn	231.92	0°.04	4	1K	2	.....	....	..	..	..	.....	....	..	.....
	231.89	.09	6	3	2	231.82	0°.08	4	3	1	.....	....	..	.....
Cd	321.01	.09	3	K	2	320.95	.02	2	1	1	.....	....	..	321.7
Pb	327.58	.01	2	1	1	.....	....	..	..	..	.....	....	..	326.9
Zn	419.37	.04	6	K	1	419.32	.08	8	3K	1	.....	....	..	.....
	.....	.11	9	3	1	.....	.16	11	5	1	.....	....	..	419.0
		$\delta = 1.516$					$\delta = 1.551$		K	1	.....	....	..	.....
	419.30	.06	5	K	1	419.28	....	1	3K	1	632.65	0°.09	2	630.6
Sb	630.71	.57	7	3K	2	631.25	.17	4	3K	1	.....	....	..	.....
M. P	630.80	.15	4	2K	1	631.06	.08	3	1	1	.....	....	..	.....
Ag-Cu, 71-29	779.55	.08	3	1	2	781.21	.06	2	..	..	.....	....	..	.....
Ag-Cu, 72-28	779.18	.45	6	1	3	.....	....	..	..	..	784.61	.14	2	.....
Ag-Cu, 73-27	779.23	.30	3	1	2	.....	....	..	1	1	975.28	.08	2	961.5
Ag	960.88	.39	8	1	3	966.21	.02	2	3	1	1106.2	....	1	1084.1
Cu	1083.04	1.61	7	B. C. W.	3	1091.92	1.15	4						
	1082.88	2.26	13	4	4	.....	....	..	..	..	.....	....	..	.....

In the table "range" = difference between highest and lowest *F.P.* determinations. "Number of samples" refers to materials from different chemical firms. "K" means Kahlbaum, "B. C. W." the Baltimore Copper Works' purest product.

Specific Heats at High Temperatures.—At the Washington meeting of the Physical Society a paper was presented by Walter P. White, of the Geophysical Laboratory of the Carnegie Institution of Washington, on specific heats at high temperatures. Since this is a matter of great importance for making chemical and metallurgical calculations, we give the full abstract from the *Physical Review* of June. A year ago, specific heat determinations at high temperatures were described in which the hot bodies were dropped from an electric furnace into a calorimeter. The calorimeter errors were negligible. The heat loss in transit was compensated and thus reduced purely to an accidental error, which the agreement of the results shows to have been very small (0.1 per cent or less). The preponderant source of error was the difficulty of obtaining uniform temperatures in the electric furnace. A longer and narrower furnace was therefore constructed, in which radiation shields above and below the charge increase the uniformity of other probably nearer the truth; their difference is well within the possible error.

If $A + BT + CT^2 + DT^3 + \ldots$ is the expression for the mean specific heat, the actual specific heat is given by $A + 2BT + 3CT^2 + 4DT^3 + \ldots$ but the actual heats thus determined contain the errors of the mathematical expression in an exaggerated degree, hence those here given for the silicates were obtained graphically. Even so, they are less accurate than the mean heats, especially at the higher temperatures (an error of 1 per cent in the mean heat at 1500 deg. may produce 1 of 7 per cent in the true heat). The apparent decrease in the silicate specific heats above 900 deg. must, therefore, not be given undue weight; but the general character of their specific heat curves, whose increase is mainly at comparatively low temperatures, is unquestionable and in striking contrast to platinum.

Quartz shows the same type, even more strongly marked, but the inversion at 575 deg., which causes a heat evolution of from 4 to 5 calories complicates the treatment of the data, and will necessitate further observations. The mean heat, 0-500 deg., is 0.2370, which is very much lower than some published values.

RECENT METALLURGICAL AND ELECTROCHEMICAL PATENTS

General Electrochemistry

Polyphase Furnace.—A rectangular three-phase furnace, as shown in Fig. 1, is patented by H. C. Harrison, for instance, for the manufacture of ferrosilicon. There are three electrode bundles 9, each bundle consisting of four electrodes, and being connected to one phase of the three-phase system. The charge 2 (silica, iron or iron ore, and coke for the manufacture of ferrosilicon) is introduced from the top. The molten ferrosilicon 3 collects on the bottom. The charge 2 above is of relatively low conductivity compared with the molten ferrosilicon 3 below. It is, therefore, possible to maintain three arcs always between the ends of the electrode bundles and the molten ferrosilicon below, and never between the electrodes themselves. The bath 3 is grounded through the refractory bottom lining 7 and metal bottom 6. In the same way the neutral point of the three-phase generator or transformer is grounded. The three electrode bundles are spaced just far enough apart to cause the molten

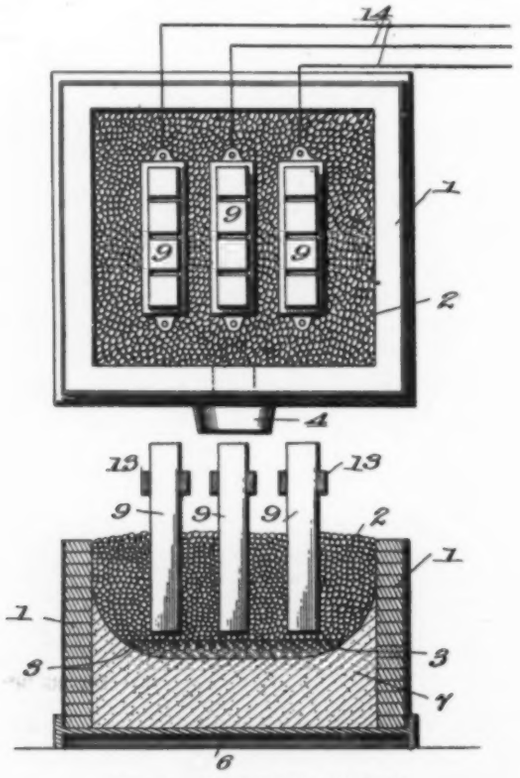


FIG. 1.—THREE-PHASE FURNACE.

bath to be always one and not three separate baths, so that only a very small current passes from one electrode to the other through the unreduced charge. When single electrodes, instead of electrode bundles are employed the furnace must be narrower. The inventor emphasizes that his furnace is quite different from three-phase furnaces working on the resistance principle, where the electrodes must be placed symmetrically in regard to the neutral point and when the furnace should be itself circular. In the present furnace it is not "essential" to arrange the electrodes symmetrically with respect to the neutral point; "it is only necessary to balance the phases by a careful regulation of the arcs maintained between each electrode and the (electrically) neutral bath." (919,165, April 20, 1909.)

Artificial Graphite.—E. G. Acheson, the founder of the artificial graphite industry, had formerly found that for the charge of amorphous carbon into graphite in the electric furnace it wac advantageous to mix the carbon with materials capable of forming carbides. He has now discovered a process whereby carbon devoid of such carbide-producing materials may be converted into the graphite form by causing metallic vapors to act upon the amorphous carbon at the high temperature of the electric furnace. Various metals, such as iron, silicon, titanium, aluminium, boron, or compounds thereof, may be used. The graphitization of petroleum coke by means of iron vapor is described as follows: Into a long electric furnace, with electrode terminals at the two ends, petroleum coke is charged, broken so that its particles vary in size from a powder to lumps, three or four inches in diameter, so that the lumps are fully and completely imbedded in the powder. Through this mixture iron oxide is scattered, or roughly mixed with it, in the proportion of five pounds of iron oxide to 100 pounds of coke. To start the operation, carbon rods are extended through the charge, in contact with each other, and with the terminals at two ends, so as to form a continuous conductor. The charge is covered with an air-excluding layer of sand and powdered carbon, in proper proportion to form carbide of silicon. With a furnace of 30 feet in length, 14 inches in width, and 18 inches deep, a current of 300 amperes at 200 volts is suitable. The current quickly increases as the result of the reduction of the resistance of the carbon rods and of the surrounding coke with rise of temperature. During the operation of the furnace, the oxide of iron is first reduced to the metallic state, whereupon with further rise of temperature the iron is volatilized and more or less fills the entire furnace, thus coming into intimate contact with the whole charge. The coke is thereby converted into soft graphite. (12,964, June 1, 1909.)

Aluminium Silicates Treatment.—Alf Sinding-Larsen proposes to treat silicates of aluminium, such as feldspath, common clay, kaolin, in an electric furnace in contact with iron (scrap iron or iron ore) and coke. The electric furnace process may be combined with an electrolytic process. The result of the treatment is the formation of a layer of fused ferrosilicon at the bottom and slag containing aluminium oxide at the top. (927,758, July 13, 1909.)

Boron as Reducing Agent for the Production of Metals or Alloys.—Fred M. Becket proposes boron, ferroboron, or borides as reducing agent for the production of chromium, tungsten, molybdenum, vanadium and their alloys. For instance, to produce low-carbon ferrochrome from chromite, use is made of the reactions $Cr_2O_3 + 2B = 2Cr + B_2O_3$ and $3FeO + 2B = 3Fe + B_2O_3$. In case a carbon boride or carbon-boron compound is employed, the proportion of boron is reduced in accordance with the carbon content, the carbon under these conditions serving also as reducing agent. The process is facilitated by the presence in the charge of a base capable of uniting with the oxide of boron produced. Most commercial chromites contain from 8 to 15 per cent. of aluminium and a similar proportion of magnesia, and to the extent of their presence these serve the purpose of a basic flux. The process is preferably carried out in an electric furnace. (924,130, June 8, 1909. Assigned to Electro Metallurgical Co.)

Alloy for Resistors.—John T. H. Dempster patents a silicon-tellurium alloy for use as a resistance material for heating units, etc. The alloy may contain from 1 to 15 per cent. of tellurium. The use of 5 per cent. of tellurium increases the resistance of silicon from three to five times without making it brittle or introducing any other undesirable physical changes in the cast material. (923,152, June 1, 1909. Assigned to General Electric Co.)

Ozonizer.—Alexander Vosmaer patents an ozonizer, consisting, as shown in Fig. 2, of a tubular casing 1, with perforated top and bottom plates 2 and 3. Extending between them are a number of rods 4, the middle portions of which constitute the electrodes 5, with serrated surfaces or made up of wire netting or gauze. These electrodes are arranged concentrically within the tubular dielectris 6, supported by means of upper and lower caps 7, by the rods 4. Arranged around and concentric with the dielectrics 6 are tubular electrodes 8 of perfo-

rated metal or gauze, supported by a perforated partition 9. The air to be ozonized is passed through the casing from 10 to 11, and passes both outside and inside of the dielectrics and through the field of electric discharges. The tubular form of the electrode units insures a large surface, so that there is a

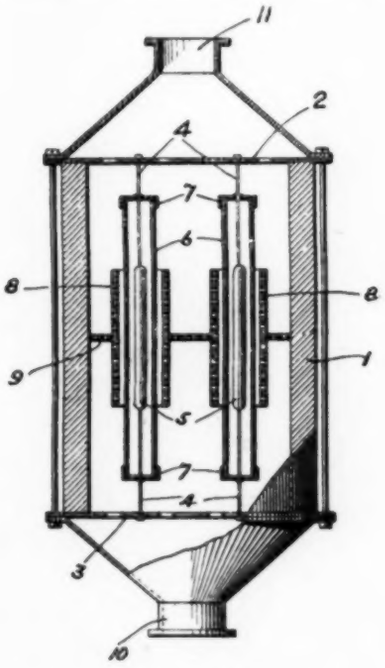


FIG. 2.—OZONIZER.

relatively low current density per square unit, which tends to protect the dielectric from undue strain. (919,403, April 27, 1909; assigned to U. S. Water Improvement Company, of Philadelphia.)

Manufacture of Insulating Compound Fiber.—Several interesting problems of physical chemistry, involved in the manufacture of the insulating compound, commonly known in the electrical art as "fiber," are discussed in two recent patents of Dr. W. R. Whitney, chief of the Research Laboratory of the General Electric Company. The problems have broadly to do with the purification of porous materials. In the manufacture of "fiber" it is customary to treat sheets of cellulose by passing them through a strong solution of zinc chloride, after which the sheets are piled one on another and compressed into a homogeneous mass. The zinc chloride is then removed by washing. This washing is usually performed in several distinct steps by suspending the porous mass in different zinc chloride solutions of diminishing concentration until pure water is reached, for it has been found that if the material is placed directly in pure water the osmotic pressure of the salt in the pores of the mass will draw in an excess of water and form water blisters. These blisters cause splits in the final product and are the cause of the great losses in material which sometimes occur even when extreme care is taken to prevent their formation by gradual rather than by rapid washing. The thicker the sheet to be produced the greater the difficulty due to osmotic pressure, and consequently the time and care necessary to remove the zinc chloride, the complete removal of which is imperative. On this account, six weeks of washing by gradual treatment with more and more dilute solutions of the chloride is necessary for sheets of an inch or more in thickness, thus greatly increasing the cost of material when made in thick masses.

The osmotic pressure of a solution depends on its concentration. The rate of diffusion of a salt from a concentrated solution to a dilute solution depends on the concentration differences of the two solutions, with respect to that particular salt alone, and not with respect to other soluble substances which may be carried in one or the other solvents. These factors Whitney makes use of by utilizing, as a solvent for the zinc chloride, a solution which is "isotonic" with respect to the zinc chloride solution to be removed. By isotonic is meant a solution having such a concentration that it will have the same osmotic pressure as the zinc chloride to be removed. Thus, for example, a solution of glycerine, or glucose in water, may be used to wash the fiber mass and thereby remove the zinc chloride employed in the chemical preparation of the mass. In this way the concentration of zinc chloride in the wash water is kept low, and consequently its rate of diffusion from the mass into the wash water is not very high. The osmotic pressure of the washing solution being high, and of any desired predetermined value, does not allow the formation of water blisters in the fiber. The solution of glycerine or glucose in the wash water is not in any way detrimental to the product. To further facilitate the removal of the zinc chloride, Whitney employs electrolytic action, yielding zinc and chlorine at suitable cathodes and anodes, respectively. By a suitable addition of alkali and acid in dilute form to neutralize the products liberated at the electrodes and to preserve the isotonic condition of the washing liquid, the process practically amounts to the replacement of the zinc and chlorine within the fiber by the components of water, which from an electrochemical point of view are H and OH ions. (923,227 and 923,745, June 1, 1909.)

Electroplating.

Metal Foil by Electrodeposition.—In order to produce electrodeposits which can be readily removed from the cathode on which they are deposited, Harry Schmidt first "polarizes anodically" (i.e., uses as anode) the electrode which as cathode is afterward to receive the deposit. To produce metal foil in

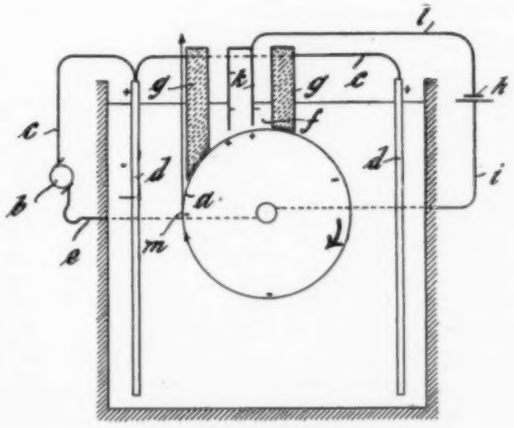


FIG. 3.—DEPOSITION OF METAL FOIL.

an endless strip, he uses the apparatus shown in Fig. 3. The metal is deposited on the revolving cylinder *a*, which is cathode, the electroplating current passing from the dynamo *b* through the wire *c* to the anodes *d*, through the solution to the cylinder *a*, and through the wire *e*, back to the dynamo *b*. This current deposits metal on the cylinder *a*. But previously the surface of the revolving cylinder has been "anodically polarized" within the space of between the partitions *g* by means of a current from the battery *h* through the wire *i* to the cylinder *a*, then to the plates *k* and through the wire *l* back to the battery *h*. If the deposited metal foil is drawn off the cylinder *a* at some point *m* before the isolated part of the bath, an endless strip of metal foil is obtained. This method can also be employed for producing extremely thin foil suitable for being ground to form bronze. A modification of the apparatus for producing an endless hollow pipe is also described. The voltage employed for the anodic polarization is 0.8 volts or less when producing thick electrodeposits, and 1.3 volts when producing nickel foil of the thickness of tin foil, and about 3 volts while producing a deposit suitable for being ground to form bronze. (916,033, March 23, 1909.)

Electroplating Hollow Tubes.—To electroplate the inside of hollow tubes. E. Friedheim uses anode rods within them, and provides insulating sleeves for the anodes to prevent short-circuiting between anodes and cathodes. Several forms of insulating sleeves in form of a perforated insulated sheathing or of an insulating ribbon, wound around the anode, are described. (915, 846, March 23, 1909.)

Plating Rack.—D. B. Moyer patents a hanger for the suspension of articles to be electroplated. It consists of a metallic rod, protected against metal deposition by a wood sheathing, with detachable metallic branch rods, projecting laterally through the wood sheathing and not protected, from which the articles to be plated are suspended. (915,786, March 23, 1909.)

Iron and Steel.

Basic Bessemer Process.—Josy Flohr patents the following process for cooling and dephosphorizing the molten charge in a basic Bessemer converter: Pure burnt lime, slaked with water, is pressed into bricks and only dried to such an extent that the calcium hydroxide remains as such in an undecomposed state. Toward the end of the decarburizing period, or later, the converter is tilted and the calcium hydrate briquets are introduced into the bath. The process is then completed by again blowing in air. (920,560, May 4, 1909.)

Tool Steel.—Jesse M. Darke patents a tool steel suitable for cutting tools for lathes, planers, milling machines, etc. It is chemically characterized by the presence of about 13.5 per cent. tungsten (or about the percentage now found in the so-called high-speed steels), by the presence of about 3 per cent. manganese (not more than 3.25 per cent. nor less than 2 per cent.), by low carbon content (less than 0.5 per cent.), and by low chromium content (less than 0.5 per cent.). (919,544, April 27, 1909; assigned to General Electric Company.)

Electric Steel Refining.—With respect to a recent proposition of O. Thallner, of Bismarckhütte, mentioned on page 326 of our July issue, another patent of the same inventor is interesting. At Bismarckhütte electric steel refining is carried out by the Heroult process. According to Thallner's present patent the steel refined in an electric furnace with basic lining is passed into a crucible with an acid fire-proof lining. The steel previously refined in the electric furnace is allowed to stand in the crucible for a few hours so that the remainder of the slag which has not been separated by the reaction in the furnace settles on the top of the material in the crucible. Thallner has found that such a separation cannot be produced by prolonged treatment in the electric furnace, for the reason that the disturbance of the material between the electrodes is too violent to permit of the settling of the finely mixed particles of the slag which have not been removed by the reaction and which are distributed through the molten mass like the constituents in an emulsion. When allowed to remain in the crucible, however, the influence of the basic-lined electric furnace is counterbalanced as in the crucible silicon, is taken up and thereby the steel receives the typical properties of what is usually called crucible steel, and the process also permits of the production of alloys of iron in a very controllable manner, or the addition of modifying agents, as is usual in the crucible process. These additions can only be added with great difficulty in an electric furnace, as the temperature conditions are so variable that when additions usual in the crucible process are made totally different results as regards grain and structure of the metal and other physical qualities are obtained. These difficulties can be avoided according to the present process by passing the steel into the crucible before the addition of the modifying constituents. Likewise the carbonizing of the steel can take place in the crucible by means of suitable known carbonizing agents. (919, 493, April 27, 1909.)

Induction Furnace.—Otto Frick, whose induction furnace has been reported to be employed at the Krupp works in Essen, patents the construction, shown in Fig. 4. The primary winding 3 surrounds one arm of the rectangular transformer iron core; the same arm is surrounded by the annular hearth 2. "The other limbs, 4*b*, 4*c* and 4*d*, of the core do not closely include the primary and secondary circuits of the transformer furnace, as is usual in ordinary transformers, but are at such distance from them that the leakage fields, when the furnace is working, do not in an essential degree pass through the iron. The limbs 4*b* and 4*c* are not in contact with the primary winding, but have a free space between them and the winding. Also between the limbs 4*c* and 4*d* and the secondary circuit is a

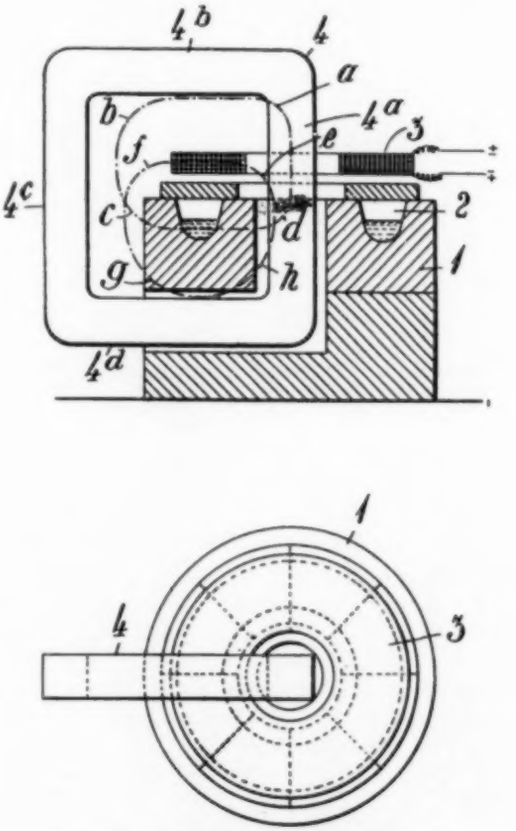


FIG. 4.—INDUCTION FURNACE.

space that is greater than the space between the primary and secondary circuits. The dotted lines *a*, *b*, *c*, *d* in the upper diagram represent the limits of the primary leakage field, the dotted lines *e*, *f*, *g*, *h*, the limits of the secondary leakage field. An essential feature of the invention lies in the possibility of designing the cross-sectional form of the primary winding without interfering with the diameter of the secondary member, while at the same time iron is avoided in the leakage fields. By the combination of a primary winding facing a horizontal side of the hearth and a magnetic core of the form above described it is possible to use a primary coil of a flat-disk form, such a coil having a high magnetic resistance in the leakage field around it, whereby the self-induction of the furnace is reduced." (917,040, April 6, 1909.)

Copper.

Precipitation of Copper and Silver by Thionates or Thionites of Iron.—G. C. Westby, of Murray, Utah, proposes to precipitate copper and silver from their solutions by means of thionites or thionates of iron. The solution for prescription can be cheaply prepared by treating slags, ferrous sulphide, iron or oxidized ores with sulphurous acids or sulphur smoke scrubbing liquor. In preparing the solution from slag—which is the cheapest method—the material is blown into wool or otherwise finely divided. It is then charged into barrels and a solution of sulphur dioxide or smoke scrubbing liquor is added, or

sulphur smoke is caused to impinge on the material in the presence of water. In order to hasten the solution, the mixture may be agitated. After allowing the suspended matter to settle, the supernatant liquor is drawn off, and is added in a suitable receptacle to the solution of the metal to be precipitated, and the mixed solution is heated to any required temperature. (923, 916, June 8, 1909.)

Zinc-Copper Alloy.—The object of a patent of T. Elliott is to produce a zinc-copper alloy at a temperature much below the melting point of copper. He first melts the zinc, then adds the copper to the molten zinc, and then raises the temperature to the melting point of the alloy, which is less than the melting point of copper and also less than the boiling point of zinc. "For example, assuming the melting point of zinc to be 412 deg. C. and its boiling point 1040 deg. C., and the melting point of copper to be 1090 deg. C. and the melting point of the alloy to be produced 973 deg. C., it will be noted that when the copper is placed in the molten zinc at 412 deg. C. it begins to dissolve, but even so, the temperature is raised to 973 deg. C. or thereabout, which is less than the melting point of the copper, and also less than the boiling point of the zinc, yet is high enough to produce an alloy having a perfectly homogeneous structure." In carrying out the process the metal is covered with charcoal or borax. (927,843, July 13, 1909.)

Zinc.

Zinc Distillation Furnace.—Woolsey McA. Johnson has devised the furnace, shown in Fig. 5, in vertical section and horizontal cross-section along line 22, for zinc ore reduction, and in general for the treatment of any charge yielding a volatile product. It has massive fire-brick walls 1, encased in a metal sheath. The walls 1 enclose a chamber 5, in which is

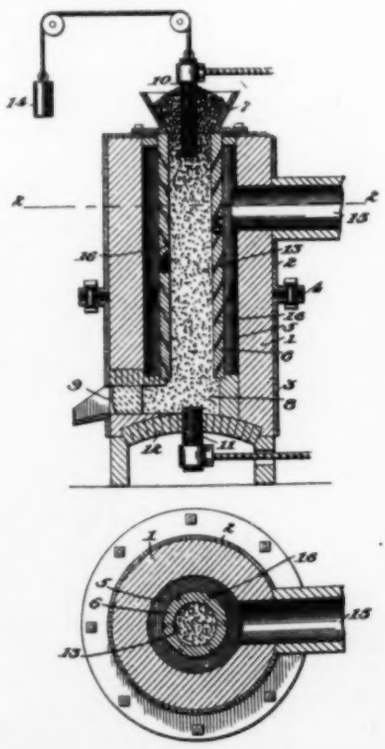


FIG. 5.—ZINC DISTILLATION FURNACE.

concentrically disposed a permeable tubular casing 6, constituting the reaction chamber of the furnace and constructed of highly refractory non-conducting material. The casing 6 communicates at its upper end with a hopper 7 and at its lower end with a chamber 8, to which access is afforded for the removal of residue by the door 9. At the top and bottom electrodes 10 and 11 are provided. The charge of zinc ore and carbon is passed from the hopper into the central chamber 13 of the furnace. The zinc vapor distills off through the upwardly inclined apertures 16 in the walls 6 into the outer ring-formed conduit 5 and then into a suitable condenser. The construction permits an easy escape of the zinc vapor from the reduction zone; the conduit 5 serves at the same time as a heat-insulator and reduces the heat loss to the outside. Instead of employing solid walls 6 with aperture 16, it is possible to use a porous casing, which is readily prepared by incorporating 10 to 20 per cent. by volume of charcoal with a refractory fireclay and afterward eliminating the same by firing. (920,473, May 4, 1909.)

Zinc Dust.—Sherard Cowper-Coles makes zinc dust or "tultz powder" by depositing zinc upon a rotating iron disk under such conditions as will insure deposition in spongy form. An electrolyte of hot or cold caustic soda solution is used with anodes of iron or an alloy of zinc and iron known as hard zinc. The current density is several hundred amperes per square foot. The zinc sponge is removed from the iron disk by means of a scraper. "The electrolyte may be regenerated in a separate chamber or vessel, and an economical form of zinc is either scrap zinc or what is known as hard spelter obtained from the baths of hot galvanizing works. The bars or slabs of zinc are suspended in the baths or tanks and the zinc deposited upon the iron electrode. In the process of regeneration a considerable amount of electric current is generated if the hard zinc is coupled to an electro-negative metal such as lead, and this may be used for a variety of purposes. For example, it can be utilized for the recovery of zinc and copper from impure zinc-copper alloys, as a low voltage and current density are sufficient for this purpose. A convenient form of electrolyte for this object is sulfuric acid, the impure brass to be treated being placed in this electrolyte and in connection with the positive pole of the electric generator composed of the zinc couples above referred to. The copper is deposited at low current density on suitable cathodes, and the zinc sulphate which is formed may be evaporated down to crystals or the zinc may be deposited by electrolysis." Zinc dust prepared by the above method is especially suitable for the process of "sherardizing" (our Vol. V, p. 187; Vol. VI, p. 189). The zinc dust must be dried in a reducing atmosphere to prevent the formation of too much zinc oxide. (723,411, June 1.)

Mercury Ammeter.

The problem of measuring large alternating currents with any degree of precision with any of the various types of instruments which have been on the market is, from a technical standpoint, a difficult one. All who have had any experience in this class of work agree that there is need for a standardization instrument, which can be inserted directly into an alternating-current circuit carrying 500 amp and over which will measure this current to the same degree of precision that small currents may be measured.

As a suggestion toward an instrument which would meet these conditions, in 1907, in a paper entitled "Some Newly Observed Manifestations of Forces in the Interior of an Electric Conductor," published in the *Physical Review*, June, 1907, Dr. E. F. Northrup proposed an alternating-current ammeter based on the forces he described. At that time a crude instrument was shown. Since that time, the Leeds & Northrup Company have steadily perfected this instrument until it has reached a point where, practically speaking, the only limit to accuracy of the instrument is the accuracy to which the ultimate unit of current is known. A paper descriptive of the developed instrument, its theory and tests of accuracy, was read by Dr. Northrup at the meeting of the American Electrochemical Society at Niagara Falls, Canada, May 6 to 8, 1909.

The Leeds & Northrup Company state that their new instrument, which they designate the "mercury ammeter," is intended for use as a primary standard instrument for large currents, either alternating or direct. It is intended for the calibration

of station instruments, and for use in the determination of series transformer ratios. However, its very small resistance, together with the absence of inductance in the instrument, open to it a number of uses in the alternating-current field which are closed to instruments possessing impedance.

The mercury ammeter is intended for use in the measurement of currents of 200 amp and over. The lowest practical range in the present type of instrument has a full scale corresponding to 500 amp and this instrument on 200 amp may be read to 1.5 per cent accuracy. The standard length of the scale is about 22 in.

Very exhaustive tests have been conducted on a number of these instruments using the potentiometer with direct current and Kelvin balances with alternating current as calibrating instruments. In brief, it has been shown that this mercury ammeter may be read over three-quarters of the scale to an accuracy of 0.1 per cent, this accuracy being totally independent of the kind of current being measured; that is, the same instrument is equally accurate upon direct current and alternating currents of any wave form, and any frequency up to 133 cycles. The scale follows the "square law," and the reading is in terms of the mean square value of the current. Also, the tests have shown that the temperature coefficient of the instrument is negligible when it is used as a standard.

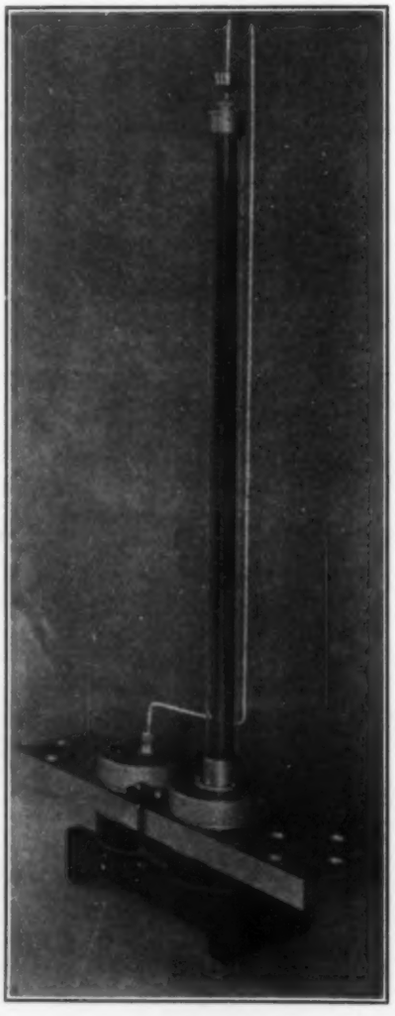


FIG. 1.—MERCURY AMMETER.

A great deal of care was exercised in the determination of the effects of external currents upon the indications of the instrument. The results showed that appreciable errors resulted only when conductors, carrying heavy currents, were placed directly over or directly under the instrument in contact with the base. For instance, when a conductor carrying a current equal to the full scale reading of the meter (200 amp) was placed over the base of the instrument parallel to its length, and in immediate contact with it, a 0.3 per cent error resulted. This was the maximum error observed, and when the distance between the conductor and the instrument was increased, the error rapidly diminished.

With regard to the constancy of the mercury ammeter, an instrument built in 1907, embodying all of the essentials of the present instrument, at the present date, shows absolutely no perceptible change.

It has a period of about five seconds; that is, it will pass from 0 to full-scale reading in five seconds. For facility of reading, the meter is built to be just short of "dead beat."

We present herewith a photograph of this instrument, which is of great simplicity of construction, with a complete absence of springs, valves, and all other mechanisms.

The operation of the instrument is quite simple. The copper terminals of the instrument are bolted into the circuit without any regard for polarities. The "zero" of the instrument is roughly adjusted by leveling, and finally by turning the thumb-nut at the top of tube. The current is then thrown on, and the colored liquid will flow up to a point in the scale corresponding to the current flowing. Current is then read directly from the scale.

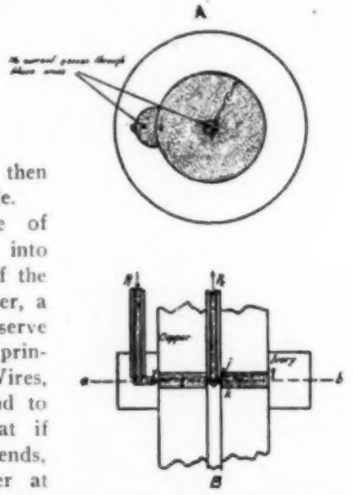


FIG. 2.—PRINCIPLE OF MERCURY AMMETER.

It is beyond the scope of the present article to go into the details of the theory of the mercury ammeter. However, a very simple analogy will serve to make clear the essential principle of the instrument. Wires, when carrying current, tend to attract each other so that if they were fastened at the ends, they would swing together at their center. We can consider a liquid conductor as being made up of an infinite number of elemental conductors, parallel to the directions of flow of the current. The right-hand and left-hand sections of the mercury ammeter are very similar in construction, and consist of copper plates alternating with insulating plates, having various holes drilled in each side and closed reservoirs for mercury.

If the current enters through one copper leaf, in order to get to the next copper leaf of the cell it must pass through the mercury-filled space within the ivory ring. The principle is indicated in Fig. 2, where A is a cross-section on the line $a\,b$ of B. When an electric current passes from the copper leaf j to k, it must pass through the intermediate disk of mercury. In doing so, it causes the mercury to tend to flow away from the edges and "bank up" at the center. The force causing this action is exactly the same force that causes solid conductors carrying current to tend to attract each other. This attraction toward the center causes mercury to flow down the tube p_1 and up the tube p_2, until this driving force is just balanced by the force due to the difference in hydrostatic head between the levels of the liquids in the two tubes p_2 and p_1.

It is an interesting fact that the ammeter consumes about one watt per inch of scale reading, regardless of the amount of current to which 1 in. of scale corresponds.

The calibration of the instrument is dependent only upon the number and diameter of the disks or cells, the density of the liquid which serves as an indicator and the force of gravity. The liquid is not exposed to evaporation and, due to the fact that the instrument involves only hydrostatic heads, the effect of variations in the diameter of the index tube is eliminated, as is also the possibility of error due to "drainage effects." Within wide limits the calibration is also independent of temperature changes.

This instrument involves the application of new principles in instrument design. Its development necessitated the satisfactory solution of a large number of incidental structural difficulties of a type totally different from those normally arising in electrical measuring instruments. The accuracy of this completed instrument, its simplicity, together with entire absence of all corrections, make it well-nigh ideal considered solely as an instrument, while the fact that it performs a function for which no other tool is at all feasible justifies the belief that the mercury ammeter is destined to occupy a position alongside of the

potentiometer and the dynamometer as a high precision standardizing instrument.

Girod Electric Steel Furnace.

Since the note in our July issue, page 323, was published, three other works have signed contracts for the installation of the Girod electric steel furnace. The corrected list is now as follows:

S. A. E., Procédés Paul Girod, Ugine, France, four furnaces.
Oehler & Company, Aarau, Switzerland, one furnace.
Cockerill & Company, Seraing, Belgium, one furnace.
Stotz & Company, Stuttgart, Germany, one furnace.
Marrel Frères, Rive de Gier, France, one furnace.
Danner & Company, Judenburg, Austria, one furnace.
Gutehoffnungshütte, Oberhausen, Germany, one furnace.
Stahlwerk Becker, Crefeld, Germany, three furnaces.
Poldihütte, Alt-Kladno, Austria, one furnace.
Ternitzer Stahlwerk, Ternitz, one furnace.
Diosgyor Staahlwerk, Diosgyor, Hungary, one furnace.
Making 16 in all, with capacities up to 12 tons.

The American representatives of the Girod furnace and process, Messrs. C. W. Leavitt & Company, of New York, state that an American works has also just signed a contract to install a Girod furnace.

Rail Handling Magnets at Gary.

During the past few years the advantages of lifting magnets in large-scale practice have been generally recognized and many new applications of magnets have been made. The Electric Controller & Manufacturing Company, of Cleveland, Ohio, as the pioneer in this field, has designed and applied new types of magnets to new kinds of service.

An exceedingly interesting application requiring a new design of magnet is the handling of the entire output at the immense rail mill of the United States Steel Corporation's plant at Gary, Ind. This mill is of the most modern design in every respect, and electric power has been used throughout, even to the driving of the rolls by 6000-hp motors. The handling of the finished rail by electric power through the use of lifting magnets was, therefore, a logical conclusion, providing a successful magnet could be made.

FIG. 1.—ELECTROMAGNET LIFTING 60-FT. RAILS.

The handling of the rail output by means of magnets was particularly desirable from the following considerations:

First—Sufficient labor alone could be dispensed with to make the application commercially attractive.

Second—A very large saving in time of handling would be effected.

Third—Very much less timber spacing material was necessary in loading.

Fourth—There being no possibility of bending the rail when loading by magnets, loss on this score would be eliminated.

While it is desirable from the standpoint of the rail mills and railroads to ship rails in locked sections, yet this is an arrangement of rails which is particularly difficult to handle with a magnet.

The difficulty arises from the fact that the top layer of the rails practically short-circuits the magnetic field and none but a very powerful and carefully designed magnet would have sufficient strength to penetrate the top layer of rails and lift the bottom layer.

The magnets, which were furnished by the Electric Controller & Manufacturing Company, have been very successful and have lifted not only locked sections of 33-ft. rails, but have also successfully lifted locked sections of 60-ft. rails with an aggregate load of 15 tons.

FIG. 2.—ELECTROMAGNET HANDLING 33-FT. RAILS.

Fig. 1 shows an electromagnet of the Electric Controller & Manufacturing Company handling a locked section of 60-ft. rails at the rail mill of the Indiana Steel Company, at Gary, Ind., the lifts being from 12 tons to 15 tons. Fig. 2 shows, at the same plant, the handling of a locked section of 33-ft. rails, the lifts being from 10 tons to 12 tons.

With equal success electromagnets are employed at Gary for handling the raw material. In the open-hearth stockyards the cranes employed for unloading the pig iron and scrap from the railway cars are equipped with electromagnets. When it is desired to release a load of pig iron, current is sent through the electromagnet winding in the reverse direction; in this manner it is stated that the load is released within half a second, while without the reverse current 12 seconds are required for releasing the load.

Electric Laboratory Furnace Exhibit.

During the summer meeting of the American Chemical Society, held in Detroit, June 29 to July 2, a special exhibit of electric furnaces was prepared for the visiting chemists at the new plant of Hoskins Manufacturing Company.

The three types of Hoskins furnaces in different forms and standard sizes were shown in actual operation. A complete connected train of apparatus, including Hoskins combustion tube furnace run on standard voltage, for determination of the carbon content of steel, was displayed. A crucible furnace of standard voltage type, in connection with a Hoskins pyrometer, was shown in use for obtaining the "recalescent" points of steel specimens. Crucible and tube furnaces of heavy wire, low-voltage type, were shown in operation at a temperature of

1200 deg. C. (2192 deg. Fahr.). These furnaces were controlled by small step-down transformers operating from the standard voltage circuit. Under working conditions of melting special nickel alloys, to be used in the production of resistance wire, the Hoskins type FC furnace was shown. This furnace produces temperatures as high as 2000 deg. C. (3632 deg. Fahr.) by means of a carbon plate resistance unit worked at low voltage.

In connection with these furnaces, a complete installation of Hoskins pyrometers was exhibited. Included in this was shown an illuminated dial meter, connected through a selective switch with several thermo-couples placed in the various furnaces on display. By moving the switch, instant indication of the temperature of any of the furnaces was shown on the meter. Separate instruments, including the well-known Hoskins portable pyrometer, were also shown.

Of particular interest were the new types of laboratory hot plates exhibited. These were in two styles, those with uniform heat distribution, and those in which the heating unit was located in the center of the plate, both producing temperatures up to 350 deg. C. (662 deg. Fahr.).

An inspection followed of the manufacture of these products. This included the resistance-wire production department, the shops assembling departments, and testing laboratories. Eighty members of the society visited the plant.

Notes.

A Record Shipment of Large Graphite Electrodes.—While the International Acheson Graphite Company of Niagara Falls may always be expected to be in position to meet the extended and varied requirements of old and new customers in all parts of the world, its facilities were recently tested in a special particularly important case, and were not found wanting. Between 1 and 2 o'clock on the afternoon of Friday, July 2, a telegraphic order, calling for the shipment of a carload of electrodes, 8 in. x 48 in., by express, was received. Their works and an express company were immediately notified. At 5 p. m. an express car was delivered on the track in front of their products building. At 5:30 p. m. a locomotive on the Niagara Junction Railroad was pulling away with the loaded car for delivery to the Michigan Central Railway. It left Niagara Falls about 6 p. m., Buffalo about 8 p. m., and very early on Saturday morning the electrodes were delivered to the consignee in Chicago, Ill. The regular shipments of the day were not interrupted, there was no overtime, and the consignees were made happy by the prompt shipment. The value of the service to the customer is more apparent when it is known that if the business judgment of the Acheson Graphite Company had not been such as to have these very large electrodes in stock, a delay of from 10 to 12 weeks would have resulted. Regular and prospective customers should always anticipate their wants as much as possible, for, ordinarily, the time period specified is consumed in getting the carbons and graphitizing them. In connection with this we may point out that there are now many signs which denote a rapid and important association or merger of electrochemical and metallurgical interests. The above shipment by express of a carload of electrodes has since been duplicated, indicating the eagerness with which engineers are engaged in applying new processes to manufacture. Confidential reports received by Electrochemical and Metallurgical Industry are to the effect that there is a most pleasing renewal of vigor in many processes using electrodes, a fact which may be accepted as meaning that the great interest taken in the convention at Niagara Falls was but the forerunner of a disposition on the part of many to promote in every way possible the advancement of electrochemical and metallurgical interests.

Mr. F. A. J. Fitz Gerald, of Fitz Gerald & Bennie Laboratories, Niagara Falls, N. Y., has returned from Europe, where he went to consult with certain large German and French interests with regard to the construction of electrical furnaces for a new metallurgical (non-ferrous) process which, they believe, will be applied on a large scale in Europe.

Mr. W. S. Osborne, of the Osborne Engineering-Manufacturing Company, has made connections with the Griscom-Spencer Company, who have arranged to manufacture and sell all the machinery covered by his patents. This includes the Osborne Pneumatic Blast Separators, Osborne Vacuum Separators, Dust Collectors, Hydrating Machinery, Osborne Gas Washing and Smoke Consuming Apparatus, and all of the machinery covered by the above mentioned patents.

Lomb Memorial.—In the presence of the 1,800 employees of the Bausch & Lomb Optical Company, a bronze and marble memorial tablet in honor of its founder, the late Henry Lomb, was unveiled on July 8 in the factory of the company in Rochester. The inscription on the tablet includes the last public utterance by Captain Lomb, which was spoken on June 5, 1908, to the directors of the Rochester Public Health Association, in reply to their request for advice. The words were: "Think of others first, yourselves afterward." The entire inscription is as follows: "Think of others first, yourselves afterward. Henry Lomb, 1828-1908. This tablet is given in testimony of our love for our true friend and counselor, who by his noble deeds and good life gave to us a rare example of simple greatness to study and emulate. By unanimous vote of the employees of the Bausch & Lomb Optical Co." In behalf of the company the memorial tablet was accepted by the president, Mr. John J. Bausch, who, jointly with Henry Lomb, founded the company more than 50 years ago.

Recording Instruments for Blast Furnace Plants.—The Bristol Company, of Waterbury, Conn., have recently issued Bulletin 103, which describes some of Bristol's recording instruments especially adapted for blast furnaces. They include the Bristol recording pressure gauges, recording thermometers, electric time recorders and the Wm. H. Bristol indicating and recording electric pyrometers.

Electric Steel Induction Furnace.—According to a recent notice in the London *Times* Supplement, the Council of Sheffield University has decided to purchase a Kjellin induction furnace for experimental purposes in the applied science department. The decision was formed principally on the advice of Sir Joseph Jones, vice-chairman of that department, who has also given £500 toward the cost of the furnace. Sir Joseph stated that he had tested and analyzed electrically-made steel, sold in Germany at £31 per ton, and had taken Sheffield-made steel at equal prices, and he had come to the conclusion that they in Sheffield were being outpaced. Sir Joseph added that he was satisfied from his own business knowledge that the time would come when the electrical process would rank among the methods of making steel in Sheffield.

Fixation of Atmospheric Nitrogen and Production of Oxygen.—In our last number we gave a description of the Cyanamide Works at Odda, Norway, and of the Linde plant for separating nitrogen and oxygen from air. It may not be commonly known that a Linde plant has been in successful operation in this country for nearly two years, at Buffalo, being employed in the production of oxygen. The Linde Air Products Company are now not only duplicating the capacity of their already extensive Buffalo plant, but are building a second factory in Chicago which will be in operation very shortly. Other plants are to be constructed next year. At the present time between fifty million and sixty million cubic feet of oxygen are being produced annually by these Linde plants.

The Vanadium Alloys Company's plant at Telluride, Col., is the subject of an illustrated article in *The Daily Journal* of Telluride of June 28. The works as originally built in 1905 were described in our Vol. IV, page 105. From the description and illustrations in the Telluride *Daily Journal* it appears, however, that the plant has been considerably enlarged during the past few years, and that quite a material further enlargement in capacity and equipment is contemplated for the near future. Mr. A. W. Brand, the president, and Mr. Tyndal Rynard, the

general manager of the company, are to be congratulated on the success of their enterprise—the pioneer works of the vanadium industry in this country. Mr. A. M. Wilson is the head chemist of the works. The product is vanadate of iron, containing 60 per cent. vanadic acid.

More Koppers By-product Coke Ovens for United States Steel Corporation.—The 280 Koppers by-product coke ovens in the Joliet plant of the Illinois Steel Company have proven so successful that the U. S. Steel Corporation has now decided to adopt the same system for the Gary, Ind., plant, where 8 batteries, each of 70 ovens, are first to be installed. The construction of the Koppers oven has been slightly simplified in a few details for the Gary plant. Each oven will be charged with 13 tons and will yield 11 tons of coke. The total daily output of coke is estimated as 6,500 tons, besides 50,000,000 cubic feet of gas, with a calorific value of 500 Brit. thermal units per cu. ft., and 80 tons of ammonium sulphate.

Oil Refining in Burma.—A recent consular report states that on account of the rapid development of the oil industry in Burma, a company has been registered in Rangoon for the manufacture of sulphuric acid for local oil refining. The company is capitalized at $160,000, which has been largely oversubscribed by local investors, including oil companies. If the project is successful, various other products will be manufactured, such as vegetable dyes, fertilizers and other articles, utilizing the alkali earth deposits of Burma. At present sulphuric acid is high, as the charges for freight, insurance, and packing add heavily to the cost price. It is now imported from Great Britain alone, last year's importation amounting to 2080 short tons, valued at $119,766, or $57.60 per ton. The duty is 5 per cent ad valorem, which, with the cost of freight, insurance, and packing of the imported article is expected to afford ample protection for the local product.

The **Scientific Materials Co.**, of Pittsburgh, Pa., has issued a new catalog of Laboratory Supplies which is the largest and most complete ever published in the United States. The book, which is bound in flexible cloth, contains 540 pages and describes over 3000 different forms of apparatus used in laboratory work, every one of which is listed in all the different sizes ordinarily used. The large number of new and improved forms of apparatus which they manufacture shows that they have been keeping pace with the advance in laboratory methods. The general arrangement and the manner in which the details have been carried out make it very easy for anyone to turn to the apparatus required and select the one best suited for the purpose intended, as everything is listed under its natural alphabetical classification and where two or more classifications suggest themselves they are cross-indexed. The 2000 different illustrations give directly a concrete and exact idea of the material with a minimum amount of descriptive matter. All ambiguous terms have been eliminated and where two or more items of the same name, but of different construction, are listed, the differences are brought out in heavy type.

Digest of U. S. Patents

Compiled by Byrnes, Townsend & Brickenstein, Patent Lawyers, National Union Building, Washington, D. C.

Electric Furnaces (Continued).

611,142, Sept. 20, 1898, R. Pignotti, F. Lori, S. Regnoli, M. Besso, and M. Pantaleoni, of Rome, Italy.

Arc type. This furnace, especially designed for the production of calcium carbide comprises a substantially air-tight chamber having side walls and an apertured roof of poorly conductive material (charcoal and kaolin), and a laterally removable carbon bottom resting on a conducting plate and having a central opening, closed by a movable carbon plug, through which opening the material is discharged into a wheeled receptacle. Extending above the furnace chamber is a shell, through the upper wall of which depends a conducting rod on the end of which is secured, by a screw thread-cement connection, the upper carbon electrode. The generated gases pass into this shell and escape through a pipe, and are burned, to preheat the charge, about a receiving hopper discharging by a screw-conveyer and laterally inclined passage into the furnace chamber. As the reactions take place in an air-tight chamber combustion of generated gases and waste of electrodes are prevented.

612,943, Oct. 25, 1898, Louis Bresson, of Lyons, France.

Arc type. To be used for producing calcium carbide. The furnace consists of an ovoid-shaped steel or iron shell to which is bolted a truncated-cone shaped fire-clay-lined iron cover. Rotatably mounted on the cover is a tightly closed hopper, through which passes a chimney for waste gases, which thus preheat the charge. The bottom of the hopper and the cover have registering openings, so that rotation of the hopper permits the charge to flow into the furnace. Secured to the furnace shell are rotatably mounted trunnion-disks having axial openings through which project the carbon electrodes movable in sockets, each mounted on two rods, mounted with an interconnected parallel-motion lever-system by which the position of the arc can be changed without varying its length. One of each pair of rods is longitudinally extensible, by operation of a motor in shunt across the arc to regulate the same. Furnace can be emptied by tipping without interrupting the current.

614,930, Nov. 29, 1898, George D. Burton, of Boston, Mass.

Resistance type. Designed for reduction of refractory ores of gold, silver, etc., containing sulphur, arsenic, etc. The cylindrical furnace body rests on piers, provided with shoulders to sustain the bottom when lowered. The top has a covered charging opening and a valved pipe with interior baffles for conveying vapors to a metal-lined liquid-containing receptacle.

The electrodes may be composed of perforated disks of an alloy of Cu, Sb and Sn, and are carried by valved metal tubes, passing through top and bottom to which the conductors are clamped. The charge, consisting of ore, cabon, and flux (common salt, chlorate of potash, or borax), is placed between the electrodes. As the current heats the charge, moisture is allowed to escape through upper electrode; roasting heat then drives off sulphur, etc., and further rise of heat successively melts metals which pass through holes in lower electrode and tap hole in bottom of furnace. As bulk diminishes, one electrode is movable to maintain contact and other electrode is rotatable to stir up the ore in the furnace.

616,906, Jan. 3, 1899, James A. Deuther, of Boston, Mass.

Arc type. Designed for production of calcium carbide. The lower electrode is a carbon plate mounted on wheels running on tracks carried by a wheeled truck. The counter-balanced square upper electrode is raised and lowered by a rack and pinion connected to operating mechanism carried on a platform, above which are four hoppers having depending tubes for feeding powdered material downwardly along each side of the upper electrode, to which is clamped a framework carrying a casing within which are mounted flat-bladed fans for delivering material into the arc. A series of telescopic casings resting on the lower electrode and of greater area than the upper electrode is raised by it as the reduction proceeds. The unconsumed material between the arc and casings protects the latter from the heat. The lower electrode is automatically reciprocated under the upper electrode. This reciprocating mechanism, together with the hopper feed, the fan delivering mechanism, and the mechanism for raising the upper electrode, are driven at the proper relative rates, by suitably arranged gearing from a common power shaft. The upper electrode can also be operated by hand.

NEW BOOKS.

Ostwald, Wilhelm and Morse, Harry W. Elementary modern chemistry. 312 pages, illustrated. Cloth, $1. Boston: Ginn.

Godfrey, Hollis. Elementary chemistry. 470 pages, illustrated. Cloth, $1.10. New York: Longmans, Green & Co.

Segerblom, Wilhelm. Tables of properties of over 1500 common inorganic substances. 154 pages. Cloth, $3. Exeter, N. H.: Exeter Book Publishing Co.

Marks, Lionel S. and David, Harvey N. Tables and diagrams of the thermal properties of saturated and superheated steam. 106 pages. Cloth, $1 net. New York: Longmans, Green & Co.

Rise and Progress of the British Explosives Industry. Published under the auspices of the International Congress of Applied Chemistry by its Explosives Section. 432 pages, illustrated. Cloth, $5.25 net. New York: Macmillan Co.

Cushman, Allerton Seward. The preservation of iron and steel. 40 pages. Paper. Washington, D. C.: United States Office of the Superintendent of Documents.

Ville, Georges. Artificial manures; their chemical selection and scientific application to agriculture; tr. and ed. by Sir W. Crookes. New ed. rev. by Sir W. Crookes and J. Percival. 385 pages, illustrated. Cloth, $3 net. New York: Longmans, Green & Co.

Workshop Receipts for Manufacturers and Scientific Amateurs. New rev. edition, Vol. 1, Acetylene lighting-drying. 540 pages, illustrated. $1.50 net. New York: Spon & Chamberlain.

Lewis, Myron H. Waterproofing; an engineering problem; reprinted from a paper read before the Municipal Engineers of the city of New York, Nov. 25, 1908. 52 pages, illustrated. 50 cents. New York: Engineering News Publishing Co.

Koester, Frank. Hydro-electric developments and engineering; a practical and theoretical treatise on the development, design, construction, equipment and operation of complete hydro-electric power transmission plants. 475 pages, illustrated. Cloth, $4. New York: D. Van Nostrand Co.

Harrett, A. H. Hydraulic tables and diagrams for practical engineers. 48 pages. Cloth, $5. New York: Longmans, Green & Co.

BOOK REVIEWS.

The Journal of the Institute of Metals. Vol. I, 1909. Edited by G. Shaw Scott, M. Sc., Secretary, 310 pages. London: The Institute of Metals (Caxton House, Westminster, S. W.). Price one guinea.

The Institute of Metals was founded in 1908 with not less than 413 "original members." The first meeting was held in Birmingham on Nov. 11 and 12, 1908, the first annual general meeting in London on Jan. 19 and 20, 1909. Sir W. H. White is the president, Mr. G. Shaw Scott the secretary.

Vol. I of the *Journal* contains the proceedings and the papers presented at the two meetings in Birmingham and London. Sir William White, in his presidential address, discussed the origin and the object of the Institute of Metals as "a specialized society which should deal with the metallurgy and manufacture of *non-ferrous* metals and their alloys, on lines parallel to those which have yielded remarkable results in regard to iron and its alloys since the Iron and Steel Institute was founded in 1869."

The papers published in this volume are "Some points of interest concerning copper and copper alloys," by J. T. Milton; "The mechanism of annealing in the case of certain copper alloys," by G. D. Bencough and O. F. Hudson (emphasizing the value of equilibrium diagrams for practical metallurgists); on "aluminium and some of its uses," by J. T. W. Echevarri (in steel metallurgy; aluminium castings; sheet aluminium; aluminium powder for paints; electric conductors of aluminium); "Notes on phosphor-bronze," by A. Philip; "Metallographic investigations of alloys," by Walter Rosenhain; "Intermetallic compounds," by Cecil H. Desch; on the "Plant used in the manufacture of tubes," by W. H. A. Robertson; on "the relation between science and practice and its bearing on the utility of the Institute of Metals," by Sir Gerard A. Muntz (discussing especially the interrelation between the work of the manufacturer, the scientist, and the engineer; insisting among other things on the necessity of bringing science down to the manufacturers' level).

It is worth emphasizing the fact that while the papers themselves cover 128 pages, the discussions (though in smaller print) cover not less than 118 pages.

Finally we may quote the concluding passages of Sir Gerard A. Muntz' paper: "Knowledge is power, but power often runs to waste, and the knowledge of non-ferrous metals has hitherto run much to waste: chiefly through jealous fear of teaching a trade opponent something, whereas he has probably long since discovered it for himself. Each individual has some cherished bit of knowledge, some trade secret which he hoards carefully. Perhaps by sharing it with others he might impart useful information; but by an open discussion and interchange he would, almost for certain, learn a dozen things in exchange for the one given away.

"General increase of knowledge would give improved practice, most likely a larger use of the materials in which a manufacturer is interested. Each would give a little and receive a hundredfold in exchange. No man knows everything; even the cleverest has lots to learn yet; and after all, with equal opportunities of knowledge, it will still be the best man who will best apply that knowledge; if members have courage and confidence in themselves, they need not hesitate to exchange their knowledge with that of their colleagues or even their adversaries. There are enormous potentialities for usefulness in this Institute, and if only it can break down those barriers of narrow-minded selfishness, and gather all the scattered items of science and practice together, there can be no doubt as to the usefulness and successful future of the Institute of Metals."

Investigation of the Peat Bog and Peat Industry of Canada During the Season 1908-9. By Erik Nystrom and S. A. Anrep. (Bulletin No. 1, Canada Department of Mines, Mines Branch.) 25 pages and 6 large maps. Ottawa: Government Printing Bureau.

Besides the renowned pioneer work on the electrometallurgy of iron and steel, the Department of Mines, Ottawa, Ontario, under its director, Dr. Eugene Haanel, is paying great attention to another problem of hardly less importance—the possibilities of peat.

A year ago the Department of Mines issued an excellent treatise by E. Nystrom on "Peat and Lignite; Their Manufacture and Uses in Europe." This first report, which gave a conservative summary of what has been actually accomplished with peat in Europe, was of great general interest and remains the best reference book of its kind.

This report is now followed by a bulletin entitled "The Investigation of the Peat Bogs and Peat Industry of Canada During the Season of 1908-9." It includes six large scale maps of the following peat bogs: Mer Bleue, near Ottawa; Alfred peat bog, about 40 miles from Ottawa; Welland peat bog, about six miles north of Welland; Newington bog, on the New York & Ottawa Railway and about 40 miles from Ottawa; Perth bog, a mile and a half from Perth; Victoria Road bog, about a mile from Victoria Road station on the Midland division of the Grand Trunk Railway.

The bulletin contains a descriptive report of each bog, showing the location, area and structure, and giving an estimate of the available supply of peat fuel with records of analyses, calorific values, etc., and should be of particular interest to those engaged in, or connected with, the development of Canadian peat sources.

A fuel-testing plant is now being erected at Ottawa, in which the value of peat for the production of power gas will be demonstrated, and the Department of Mines proposes to carry on a very thorough investigation of this subject.

Copies of the above Bulletin and Report on Peat may be had on application to Dr. Eugene Haanel, Director of Mines, Ottawa.